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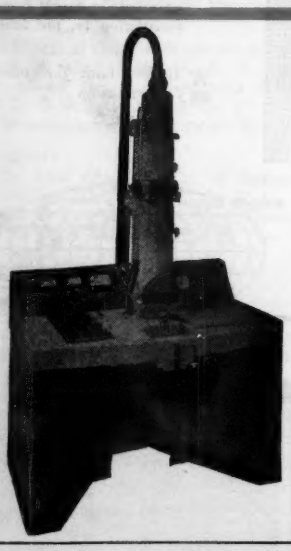

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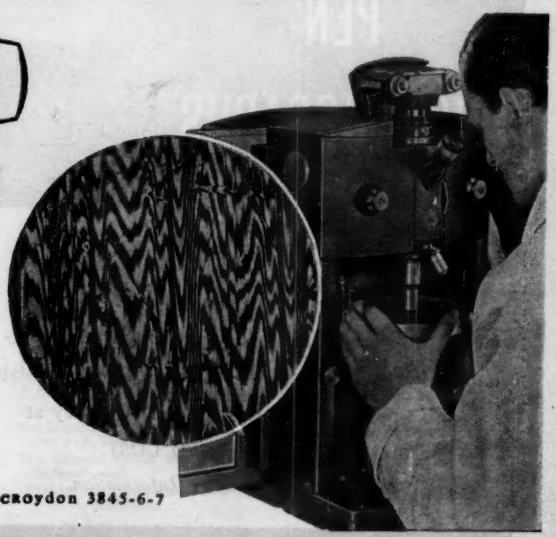

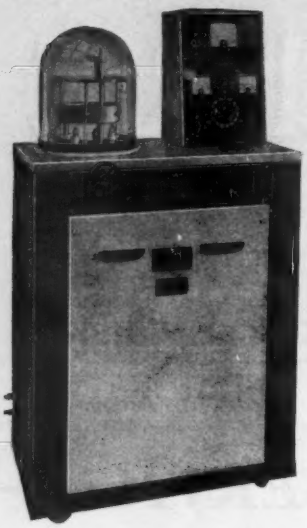

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ADMINISTRATION AND DEFENCE IN A TECHNICAL AGE

"WAR, even in or especially in an atomic age, is too serious a matter to be left almost exclusively to professionals, professionals trained in an ancient art rather than in the spirit of modern science." Thus, Prof. D. W. Brogan concludes his essay on civilian and military power in the United States in "Soldiers and Governments: Nine Studies in Civil–Military Relations", edited by M. Howard (pp. 192. London: Eyre and Spottiswoode, 1957). In this essay, Prof. Brogan suggests that no aspect of American government in this age requires rethinking more urgently than the problem of the relation between the Defence Department and the American political system, and that the days are long past in which the Service departments could be left to decide and to provide for the technical needs of the defence of the United States. The technological revolution which began on the New Mexican proving grounds of Los Alamos, argues Prof. Brogan, made the constitutional conceptions of the American system largely irrelevant, and it also brought out certain weaknesses in the administrative methods of the American Service departments which are no longer tolerable and are now becoming dangerous. The most interesting point which Prof. Brogan makes in this essay, however, is in regard to education. The central power house of American offence and defence, he asserts, is no longer in the Springfield Arsenal or even in the New London Navy Yard, but in the Atomic Energy Committee. "The higher Civil servants in England who staffed the Admiralty and the War Office might not have received an adequate technical education to discuss these questions, but they knew far better than did the military bureaucrats of the Pentagon how the physicists should be handled. Oxford and Cambridge provided a better education for this function than did Annapolis or West Point."

Clearly, President Eisenhower will need to delve deep into educational issues if he is to have any permanent and far-reaching result in the attempt to secure more effective co-ordination between the three Services foreshadowed in his Budget message and give real meaning to the office of Secretary of Defence. Mr. R. Blake's essay on Great Britain in this same volume, however, should discourage any complacency over this tribute to either British organization or methods, and Mr. M. Howard's introductory essay takes us to the root of the problems which are raised both for soldiers and for governments. The dialectic between freedom and security lies at the basis of all political society, and though, as indeed in the Bermuda discussions between President Eisenhower and Mr. Macmillan, the forms of that problem may change, the problem itself is likely to be with us until society itself is dissolved.

As Mr. Blake shows in his introduction to the volume, the issues to-day are immensely more complicated—not simply the decision as to what proportion of the national income should be spent on the Armed Forces, but also what form our defences should take and, most difficult of all, what proportion of defence expenditure should be allotted to immediate needs and what to long-term development and research. The debates in Parliament over the recent report on defence have brought out sufficiently what complications and difficulties are encountered in attempting to decide for what sort of warfare we should prepare and what part should be played by each of the three Services and, as Mr. Blake is also careful to note, these problems are debated in a climate of opinion which regards the promotion of national welfare as the highest function of the State. Indeed, it could be argued that a powerful section of opinion even puts recreational interests like television before industrial or economic development.

In such a position, we do not need to enter on those far-reaching problems of the reorganization of economic life which, as Mr. Blake points out, may be involved in defence policy, to realize the fundamental importance of educational policy at all levels. What may be remarked here, however, is that there would seem to be a *prima facie* reason for those destined for commissions in the Services to be educated side by side with those taking up civil careers, at least as far as the university-level. The clearly marked trend in the post-war entry to the Services in Britain would thus seem to be in accord with a genuine need.

There are, of course, other issues involved in the message which President Eisenhower sent to Congress early in April, though what he proposed still falls short of the unification of the three Services decreed by Congress in 1947. To the scientist in Britain, possibly the most interesting proposal in that message, and also the one which is encountering most opposition, is that which would give the Secretary of Defence complete power over research and authority to distribute appropriations among the Services to meet new situations. Quite apart from any other consideration, this suggestion is only likely to be effective and perhaps workable in the appropriate educational climate.

Much the same is true of other proposals. The Chiefs of Staff were given a chairman in 1949 and they are now to be empowered to delegate most of their Service responsibilities, with the result that the unified commands, which would themselves be created by the Joint Chiefs of Staff, would be responsible to the latter as a whole, acting in the name of the Secretary of Defence. The Secretaries of the Army, Navy and Air Force would become simply assistants to the Secretary of Defence concerned with administration, supply and training for their respective Services, but with no control over overseas or field commands. Promotion to the highest ranks, from which commands would be filled,

would be at the discretion of the Joint Chiefs of Staff, and the Staff Director would be named by the Secretary of Defence.

It is the educational implications of these proposals, rather than analogy or differences with British organization for defence, that are of most interest and significance in relation to the utilization of scientific and technical man-power and technological advance to-day. To end Service rivalries in the United States by giving virtually unlimited powers to the Secretary of Defence may not of itself eliminate indecision and provide the speed and flexibility needed alike in local or global war. Even if the new authority is fully in touch with the Services themselves and their problems, co-ordination will scarcely be effective unless the understanding and co-operation of the Services are secured at junior as well as senior levels. This is partly an educational problem, of encouraging junior officers to think in overall terms of defence, to be alert to recognize even minor opportunities for inter-Service co-operation at the supply-level or in matters like pay and rations. It is a question of outlook and of a new approach to many technical matters which appropriate training could assist.

President Eisenhower's initiative should stimulate constructive thinking in Britain on a number of problems which offer wide opportunities for economy in materials and man-power and for increasing the efficiency of our defence effort. Whether those opportunities are recognized and used depend a good deal on whether sufficient receptivity to new ideas is encouraged, and this in turn on the appropriateness of the training which is given both to civilians and those in the Services, and not exclusively to officers. Defence requirements stand on all fours with the civilian needs to which such forcible expression has been given in recent months.

In his James Forrest Lecture to the Institution of Civil Engineers on March 18, for example, Sir John Cockcroft suggested that a type of engineer should be trained who had a thorough grasp of the basic principles common to all engineering, and who was not just narrowly trained in the techniques of civil, mechanical, electrical or chemical engineering. "One of the greatest problems in the rapid build-up of atomic energy," said Sir John, "has been the shortage of engineers who can take charge of the design and building up of a complete project and who can, with their scientific colleagues, speed the development of really cheap power for nuclear energy. I am sure that this will apply to other fields of engineering in future." Again, Sir Hugh Beaver, pausing in his presidential address to the Institution of Chemical Engineers on April 30 to note how small a part of our administrators and legislators have had any scientific training, ascribed to this fact some of the difficulties in obtaining adequate support and encouragement for scientific education and research in Britain. Sir Hugh urged that more should be done to produce both the attitudes of mind and the conditions which would divert an adequate proportion of our financial resources and man-power into the use of research, and this is equally true of defence as in the civil field. The two are much too interlocked for any shortcomings in this respect in one field not to be felt in the other. For example, although the expenditure of the Ministry of Supply on research is to be cut by only £6 million to £217·4 million for the coming financial year, with a further £3·3 million off the cost of work at its research establishments, since the effort put into nuclear weapons and ballistic missiles is rising, the reduction in genuine fields of research may well be severe, even if research in nuclear weapons and ballistic missiles is not exceptionally expensive.

That of itself points to the soundness of some of President Eisenhower's proposals, and further support for them and especially for the view that the key problem is education is forthcoming from the Lees Knowles Lectures, "Cabinet Government and War", given by John Ehrman last year and recently published*. Mr. Ehrman's lectures follow naturally on Lord Hankey's lectures in 1945, "Government Control in War", and although he does not include in his survey the changes made during the stress of the Second World War, he brings into clear relief the essential administrative problems of defence which confront a democratic system of government such as that of Britain. Mr. Ehrman is concerned primarily with defence organization as an aspect of Cabinet government, although he does not limit himself to that aspect, and while he does not, like Lord Hankey, enunciate specific principles, Lord Hankey's principles are implicit in much that Mr. Ehrman writes. Indeed, unless final control remains in the hands of statesmen, working in the closest co-operation with the Service chiefs, with the Prime Minister of the day alone as head and the last word even in the grand strategy, Mr. Ehrman's lectures are of academic interest only.

Mr. Ehrman notes three main developments in the Cabinet system between 1940 and 1945. The Prime Minister's exceptional political authority enabled him to make exceptional use of his professional Service advisers, so that supreme control was exercised by a professional and not by a political committee, functioning under the ægis of the Heads of Government, while within the Cabinet system the Service Ministers disappeared from the inner counsels. Second was the creation of a powerful and extensive structure of civil committees of the Cabinet, comparable with that of the Committee of Imperial Defence, and this more effective and highly articulated hierarchy left its mark on post-war practice. Third, and in consequence, the War Cabinet itself was seldom used as an agent of administration even at the highest level, and Mr. Ehrman observes that Cabinet government, bearing its traditional responsibilities to Parliament, never functioned more effectively than during those years of war.

Throughout those years and the fifty preceding years, with which he is primarily concerned, Mr.

* Cabinet Government and War, 1890–1940. By John Ehrman. (The Lees Knowles Lectures, 1957.) Pp. xi+138. (Cambridge: At the University Press, 1958.) 16s. net.

Ehrman believes we can recognize a continuous process and that the central organization for defence has developed in an orderly way, thereby helping to preserve the essentials of Cabinet government and also those of the Parliamentary system within which Cabinet government operates—although with powers largely alien to a happier generation. It has been, he argues, one of the factors which has enabled Britain to adjust its economy and its political institutions, without violent interruption, to the burdens of total war. Mr. Ehrman emphasizes the debt which is owed to such men as Balfour, Haldane, Lloyd George and Churchill among Ministers, and to Sydenham Clarke, Hankey and Ismay among officials, but he does not minimize the importance of the system. That in turn had its effect on the men who used it, and the achievement which Mr. Ehrman stresses in these lectures is the re-incorporation of the higher elements in the Services, from their isolation in the nineteenth century, into the structure and habits of British administration.

This achievement, as he points out, was itself part of a more extensive and notable process, namely, the re-incorporation of one of the three classic activities of government, after a long period of virtual disuse, into the framework and traditions of government as a whole; and in that concluding sentence he displays the meaning of his study for all who are concerned not simply with the effectiveness of our organization for defence, but also with the relations between science and government upon which that effectiveness largely depends. The way in which the Services have been brought back within the orbit of the Cabinet holds lessons to be pondered by all who seek to improve the relations between science and technology and government, the administration of research and development, the balance of our scientific effort and the ways in which science and technology can make their full contribution to national welfare and defence. Outstanding among those lessons is the importance of the administrator and the expert, whether Service chief or scientist or technologist, being able to speak the same language; and we are once again reminded of the over-riding importance not merely of training the scientist or technologist so that he is competent to take wide views and assume high responsibility, but also the administrator and legislator, from statesmen downward, to be competent to appraise scientific and technical factors in a situation, to appreciate the significance of expert advice and to make judgments which take full account of the facts and are not warped by prejudice. While there is much in these lectures that suggests that the general form of President Eisenhower's proposals for the re-organization of defence in the United States is fundamentally sound and incorporates the lessons of British experience, it is on these latter lessons that they should direct fresh thought. To secure flexibility and understanding and receptivity demand, above all, attention to the educational issues as a matter of urgency and outstanding importance.

LEEUWENHOEK'S CORRESPONDENCE

The Collected Letters of Antoni van Leeuwenhoek Vol. 5. Edited, illustrated and annotated by a Committee of Dutch scientists. Pp. xi + 457 + 36 plates. (Amsterdam: Swets and Zeitlinger, Ltd., 1957.) 145*s*.

THE first four volumes of this exhaustive and beautiful edition of the works of Leeuwenhoek were reviewed in *Nature* in 1939 (144, 956), 1946 (157, 3), 1949 (163, 192) and 1953 (172, 696). The first five volumes of the twenty or so to be published have taken more than nineteen years to produce, and unless this rate can be speeded up very few of the present generation will still be living when the last volume appears. The present volume deals with only eight letters, of which numbers 86 and 87, 1685, have not been recovered, and are known only from brief extracts incorporated in later letters. They were concerned with the biology of the cochineal insect, at first wrongly interpreted by Leeuwenhoek, but on which he made some important observations in his later work.

The following letters, all written in 1685–86, are among those examined in this volume. In letter 82 (43) —figures in brackets are those of the earlier enumeration of the letters—crystals of a variety of liquids are described and figured, and it is noted that a gastrolith is absent in the crab, but present and obvious in the lobster. A bitch was dissected, and a quantity of material was found in the genitalia, but the spermatozoa are not mentioned in the letter, although they had already been seen and described by Leeuwenhoek in 1677 and 1679. In letter 83 (44), 1685, the obsolete term 'mishmash' appears in the English translation, although George Eliot uses it, and more recently, Lewis Carroll. In his work on crystals, in which he was greatly interested, Leeuwenhoek always used impure mixtures, which are hence often difficult and even impossible to identify, and in any event the resolving power of his microscopes was not sufficient for the purpose. The impregnated uterus of a bitch was dissected and he found in it "an enormous number of living animalcules" which he assumes are the "male seed" of the dog.

In letter 84 (45), 1685, the original seventeen figures have been lost, but six figures appear in all early printed versions except one, where there are only four. This is the famous letter on generation—a subject to which Leeuwenhoek devoted so much time and thought. The two parties in the controversy were the ovists, who maintained that the embryo was developed from an egg, as Harvey believed, and the animalculists, who held with Leeuwenhoek that the spermatozoon was a microscopic undeveloped fœtus complete in all its parts, although they were too small to be demonstrated by the microscopic equipment of the time. The ovists denied that the male seed ever reached the uterus, a belief denounced in the strongest terms by Leeuwenhoek as the most foolish and crude proposition accepted among physicians. Although Leeuwenhoek rarely expresses himself in language explosive and contemptuous, he admits that he is only an amateur anatomist, but is not dismayed that there are at least seventy authors opposed to his views on the spermatozoa. He compares the spermatozoon with the tadpole of Amphibia, but recognizes that the tail of the tadpole does not drop off, although that of the sperm does.

He attempts to determine the rate of movement of the latter, but is, of course, wrong in assuming that males and females can be distinguished. In this letter Leeuwenhoek describes also the complex structure of a sheep embryo seventeen days after the parents had mated. Having discovered all its essential parts, as he thought, he was induced to support the preformation doctrine of animal development. When Leeuwenhoek refers to shagreen "leather" the editors of the present work do not consider that he had in mind the *untanned* skin of certain cartilaginous fishes, but a product of the skin of mules and horses. It is perhaps more likely that he used the term as it was understood in England before his own time. Leeuwenhoek expresses great annoyance that his embryological observations are distorted and misunderstood, and have hence been falsely described in printed versions.

Letter 85 (46), 1685, is largely botanical and deals with the structure of a number of seeds, and how the embryo of the plant arises from them. He repeats that the spermatozoon is nothing but a miniature of the animal into which it will develop, but admits that he cannot assert this "with the slightest degree of certainty", and that therefore we must await the discovery of spermatozoa large enough to demonstrate their complex structure. He rejects spontaneous generation and claims that the only function of the female sex is to provide the male seed with the substances by which it is nourished and induced to grow. He discusses the nature of hybrids and the results of crossing different species. He holds that, as regards himself, it was becoming more and more irrefutable that an animal can arise only by the development of a spermatozoon in the uterus of the female, but how this is brought about he admits he cannot imagine.

Letter 88 (47), 1685, deals largely with chemical experiments on various liquids and solids (for example, gunpowder) and includes little new biological material. The origin of the chyle or milk vessels is briefly discussed, and the fibrous structure of the optic nerves of the ox and horse is assumed to carry a new substance from the brain to the eyes for their maintenance. The scales of fishes are covered by a slimy membrane the nature of which is investigated. This induced him to examine the scales of other fishes such as the eel, bream and perch, and finally the structure of the human skin. It is characteristic of Leeuwenhoek's work in general that it is by nature comparative—having discovered an interesting feature in one type he is always tempted to examine it in other related forms.

The last letter, of 95 pages, in the volume is number 89 (48), 1686, and is concerned entirely with chemical investigations into the nature of cinnabar, gunpowder, saltpetre and "crab's eyes" (gastroliths).

The present volume of this important series is completed by 95 pages comprising a list of contributors, a bibliography with biographies of authors quoted, indexes of names and subjects, a list of the figures and illustrations, and thirty-six plates.

The Leeuwenhoek Commission is to be warmly congratulated on maintaining the very high standard of book production which characterizes this series, notwithstanding the far higher cost of this volume. In one respect the present volume is superior to its predecessors in the improvement of the English translation, in which only the following slight blemishes were detected: p. 41, note 53, for 'gluery' read 'gluey'; p. 105, line 10, for 'consnsted' read 'consisted'; p. 141, note 3, 'tot' is not used for 'to' in modern English; p. 145, last line but one, for 'my' read 'me'; p. 149, note 13, read 'which'; p. 169, de Graaf's name wrongly spelt; p. 185, for 'unsearchable' read 'difficult'; p. 291, note 12, line 1, add 'neither' before 'head'.

F. J. Cole

ISAMBARD KINGDOM BRUNEL

Isambard Kingdom Brunel
A Biography. By L. T. C. Rolt. Pp. xii + 345 + 17 plates. (London and New York: Longmans, Green and Co., Ltd., 1957.) 25*s*. net.

THIS eminently attractive and readable book traces a career that abounds in both technical and dramatic interest. Mr. Rolt, as a trained engineer, writes with understanding of the technical problems which Brunel had to face. He is seen here at the age of twenty, as engineer-in-charge of the Thames tunnel workings, where he narrowly escaped death in a sudden inundation. There is the building of the Great Western Railway, the South Devon 'atmospheric' railway fiasco, and the construction of the great Saltash bridge. Mr. Rolt then turns to Brunel's steamship ventures: the P. S. *Great Western* and her pioneer crossing of the Atlantic under sustained steam power; the *Great Britain*, first iron-hulled and first screw-propelled Atlantic steamer; and, finally, the monstrous *Great Eastern*, an over-ambitious project, forty years in advance of its time.

That a man of such impact should have made enemies is almost inevitable. For example, Arthur J. Maginnis in his book "The Atlantic Ferry", published in 1892, wrote with reference to the *Great Eastern* that she "was eventually broken up at New Ferry, on the banks of the Mersey, almost in the same year (1890) that the *Great Britain* ended her career at the Falkland Islands, representing with the broad gauge on the railway, now also doomed, the last of the costly and bitter memories of the engineer Brunel, who, unfortunately for many, had more influence with great capitalists than other far more capable and less fanciful engineers".

After the turn of the century, however, the bitterness of such attacks had moderated; and in 1910 *The Engineer* said of him: "In all that constitutes an engineer in the highest, fullest and best sense, Brunel had no contemporary, no predecessor. If he has no successor, let it be remembered that . . . the conditions which call such men into being no longer have any existence".

Now in 1958, the centenary year, John Scott Russell's original model for the *Great Eastern* is still on exhibition to the public at the Science Museum in London, while his huge working model for the oscillating paddle engines, the largest of their kind ever constructed, revolves majestically in the background. In contemplating these authentic relics, one feels a certain grandeur rising above the sordid history of disappointment, failure and recrimination, which was directly responsible for Brunel's premature death.

In the preface to his book, Mr. Rolt mentions that he was at first inspired by curiosity as to Brunel's personality, rather than hero-worship; but one suspects that hero-worship must have come later. Mr. Rolt is an experienced writer, with a vivid and eloquent pen, and the reader may well be caught up in his enthusiasm. However, Mr. Rolt's is also a disci-

plined pen; he gives us a balanced and therefore convincing portrait of Brunel, as a man of exceptional talent and courage, the over-ambitious author of the broad-gauge railway and the premature giant steamship of the nineteenth century, a man whose outstanding achievements and failures alike bore the stamp of greatness.

H. P. SPRATT

COMPUTERS

Digital Computer Components and Circuits

By Dr. R. K. Richards. Pp. vii+511. (Princeton, N.J., D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1957.) 64*s*.

Digital Computer Programming

By D. D. McCracken. (General Electric Series.) Pp. viii+253. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 62*s*. net.

Mathematics and Computers

By George R. Stibitz and Prof. Jules A. Larrivee. Pp. viii+228. (London: McGraw-Hill Publishing Company, Ltd., 1957.) 37*s*. 6*d*.

THE above books, although all relating to digital computers, are very different in subject-matter and interest. "Digital Computer Components and Circuits" is a companion to a well-known book by the same author, entitled "Arithmetic Operations in Digital Computers", which deals with the logical design of the switching circuits used for various purposes in digital computers. The new book covers a much wider field, and the treatment is sufficiently detailed and comprehensive to make the book useful to engineers established in the field as well as to newcomers. It is notoriously difficult to write a good book on electronic circuits but the author has succeeded in doing so. He has brought together a great deal of design information otherwise only obtainable from scattered papers and has included much original discussion and comment. Subjects treated in the various chapters are as follows: switching circuits using diodes, vacuum tubes, transistors, and magnetic cores; magnetic and other forms of storage; circuits and tubes for decimal counting; analogue-digital conversion.

The second book is intended to provide a basic course in digital computer programming, and is of interest in that it is based on a hypothetical machine with an order code so chosen that all the basic techniques used in programming for any machine of the single-address type can be illustrated. The use of such an order code enables some of the stumbling blocks inherent in programming for a real machine to be avoided. No one, of course, can become a qualified programmer without experience in the practical running of problems, but the book is realistic in its approach, and should be useful to those who do not have access to a machine or who wish to make a preliminary study of programming before beginning work in earnest with a particular machine.

The third book, by Stibitz and Larrivee, is addressed to laymen. The authors set out "to present the computers as sober, unintelligent, but useful tools in the increasingly important applications of mathematics to science, technology, and business, and not as the weird and superhuman intelligence of science fiction, the popular press and, less forgivably, of some scientific writers who should know better". In this they have succeeded, although the technical level of the book is uneven, and in places the approach to the subject strikes one as being dated. The treatment of programming for modern digital computers is weak, and suggests that the authors have had little experience in this field. In the years just before and during the War, Dr. Stibitz was at the Bell Telephone Laboratories, and was a pioneer in the design of digital computers using telephone relays. Some sections of the book reflect his experience although, as is to be expected in a book intended for laymen, the information given does not add anything to what is obtainable elsewhere. Although the authors have, in general, been cautious about what they say, in their short section on language translation they may convey to some readers the idea that the use of digital computers in this field is more advanced than it actually is.

M. V. WILKES

FOUNDATIONS OF THERMODYNAMICS

Elements of Classical Thermodynamics for Advanced Students of Physics

By Dr. A. B. Pippard. Pp. vii+165. (Cambridge: At the University Press, 1957.) 25*s*. net. Clothbound; 15*s*. net. Paper covers.

THE first introduction of the fundamentals of thermodynamics to a student is necessarily of a brief and dogmatic nature and often he has attained no more than a facility for manipulating thermodynamic relations before he is diverted to other studies. Thus the re-examination of the fundamentals in the light of greater knowledge does not take place, and there is a growing need for this deficiency to be supplied. It is therefore a pleasure to welcome Dr. Pippard's book, which is concerned with the task of propagating a firm understanding of the bases of thermodynamics among students with a moderate acquaintance of the structure.

The first four chapters are devoted to establishing the zeroth, first and second laws of thermodynamics. While familiar enough in outline, the argument is very detailed, and every likely cause of confusion or ambiguity is carefully exposed and discussed. In most cases, the argument is presented in several different ways; thus reversible work is considered in detail not only in the standard case of a fluid under pressure, but also in the case of a body in a magnetic field; while the second law is developed both by consideration of Carnot cycles and of Carathéodory's law, the complementary nature of the two arguments being clearly brought out. The following chapters introduce the temperature scale, the thermodynamic functions and their derivatives, and their applications to simple systems. There follows a discussion of the thermodynamic inequalities in which the relations between entropy, availability, and energy functions are carefully explored and lead to the conditions for equilibrium. The consideration of phase equilibria in a simple substance follows, the last example, superconductivity, leading into the final chapter on high-order transitions, where order is introduced into this rather confused subject with a firm hand.

The book forms a nodal point, at which is drawn together the basic ideas the final-year student may be expected to know, their validity and limitations

studied, and the way in which these ideas are used pointed out. At no time does the author content himself with dogmatic statement, and if an argument should lead too far from the main stream of this book the conclusion always gives the source in which the next stage of information can be found. Clarity is not sacrificed to brevity, and the writing flows smoothly from logical step to step.

There can be no hesitation in recommending this book to all undergraduates and postgraduates interested in thermodynamics, and many users of more advanced thermodynamics might well find pleasure in a study of this well-written account. The production of the book is of the usual standard of the Cambridge University Press, and, bearing in mind the preferred reader, it is good to see that an edition is available in paper covers at a substantial reduction in price.

S. Angus

DISEASES OF BIRDS

Tratado de Doenças das Aves

Por J. Reis e P. Nóbrega, com a colaboração de A. S. Reis, R. C. Bueno e M. Giovannoni. Vol. 1: Pp. 391. Vol. 2: Pp. 416. Vol. 3: Pp. 318. Vol. 4: Pp. 428. 2a Edição, revista e ampliada. (São Paulo: Ed.ções Melhoramentos.) n.p.

To undertake the compilation of a comprehensive work on a subject so enormous and ramifying as the diseases of birds requires courage. To complete such a work and present it in a manner that makes it of the greatest use, to both veterinary practitioners and students, is an achievement that does credit to the painstaking care and ability of the authors.

The "Treatise on the Diseases of Birds" by J. Reis and P. Nóbrega is now published in its second edition. The work was originally published in four volumes but in the new edition Vols. 1 and 2 and Vols. 3 and 4 are bound together to form two books only.

It is natural that the main bias of the work is toward the diseases of domestic poultry since it is in this field that the majority of work has been carried out, but information on matters of academic interest concerning wild birds is also included. The bibliography has been brought up to 1952 and, in some cases, more recent references are included. This fact alone will make the work useful even to those unable to read the Portuguese text.

The diseases are classified under their causative organisms. Thus, Part 1 is concerned with virus diseases, Part 2 with bacterial and fungal infections, Part 3 with diseases caused by Protozoa and parasitic arthropods and the last part deals with helminths and nutritional disorders. In Part 4, there are also sections on the pathological lesions of the organ systems, poisons, abnormalities of development, hygiene and a brief summary of surgical and general therapeutic measures.

In the parts dealing with virus and bacterial diseases the arrangement of the work is similar: the diseases are considered separately and a chapter is devoted to each. These chapters are in the nature of a complete account of the disease concerned. They begin with a synonymy of the common names of the disease in many languages, followed by a brief historical introduction and sections on geographical distribution, etiology, pathogenicity, symptoms, pathology, etc. At the end of each chapter is a bibliography of papers relevant to the disease under consideration.

The arrangement in Vols. 3 and 4 is slightly different in that the subject-matter is parasitological and each group of parasites is introduced by a brief general systematic account. The protozoan species recorded from birds are tabulated according to their hosts and are then discussed in groups with subsections dealing with the diseases in individual hosts. A somewhat similar arrangement has been used for the parasitic arthropods, but no keys for identification are given, and the whole group is dealt with from a systematic point of view, rather than by hosts. In the final volume the treatment of the various helminth groups is different. The nematodes are considered in groups according to the organs of the hosts in which they are found; the majority of the section on trematodes is devoted to lists of species found in both domestic and wild birds, again separated according to their site in the hosts; and the cestodes are dealt with in a similar manner except, of course, that position within the host is of little importance so far as the adult worms are concerned.

Vol. 4 closes with a general bibliography, eight coloured plates of pathological conditions and a comprehensive and most useful index.

It is realized that this account of the work does little to evaluate its merit in detail and, indeed, this would be a difficult task in view of the enormous field covered. The value of the inclusion of so much systematic detail in the helminthological sections is, perhaps, doubtful, since these groups are dealt with by many specialized works in a rather more satisfactory manner than is possible in this type of publication. In making this criticism I am undoubtedly biased by my own field of work.

In conclusion, it is perhaps best to summarize by suggesting that an English translation of the treatise would prove of great use to many people.

C. A. Wright

ENTOMOLOGY IN REVIEW

Annual Review of Entomology

Vol. 3. Edited by Edward A. Steinhaus, in association with Ray F. Smith. Pp. vii+519. (Palo Alto, Calif.: Annual Reviews, Inc., 1958. Published in co-operation with the Entomological Society of America.) 7 dollars.

The editors of scientific reviews have two main tasks; one is to ensure they get authoritative articles of current interest covering a wide range in the specialized field, and the other is to maintain a high scientific and literary standard in these articles. The reviewer of reviews may also consider these two aspects of policy and practice, and when the first two volumes of the "Annual Review of Entomology" were noticed in *Nature* (179, 1150; 1957) certain criticisms of the general policy were made, the main point being the disproportionately large number of articles devoted to the chemical control of insects. In the third volume, just issued, the balance is somewhat redressed, only 21 per cent of the space being devoted to insecticide work as against 35 per cent in both the preceding volumes.

The result is a book of better balance and much wider general appeal than hitherto, and it is clear

from the preface of the work that the editorial committee is alive to its responsibilities in this respect. It points out, with justification, that the "Review" is not a one-volume work, the implication being that judgment should be suspended until a number of volumes are available. But if policy is still to a certain degree fluid it is now that constructive criticism would be most valuable.

One thing which is not yet clear is whether the editors want to make this review international, both from the point of view of contributors and consumers. That the one depends on the other to a certain extent cannot have escaped their notice, and yet in all three volumes more than 60 per cent of the contributors have been American. It is, no doubt, easier for the editors to maintain liaison with American authors and thus uphold the generally high standard of papers; but the dangers of excessive insularity appear not only in the choice of writers but also in their papers, several of which contain bibliographies which make it appear that their author is unaware that entomological research is also carried on outside the United States.

The useful practice of carrying articles on the same subject in successive volumes, by various authors of differing viewpoint, is again in evidence with the third article on the "Dynamics of Insect Populations", the current one being by A. J. Nicholson, who restates the evidence and replies to the criticisms in previous articles of the theory of density-dependent factors. Such a valuable series of papers underlines the advantage of a continuing, as against a one-volume, review. Insect physiology is well represented in the present volume by papers on the nervous system by K. D. Roeder, the uses of sounds in insects by H. and M. Frings, two papers on the nutritional requirements of insects by W. G. Friend and J. M. Legay, and perhaps above all by a short but most valuable paper by E. S. Hodgson on "Chemoreception in Arthropods" in which the author describes the new methods recently developed by himself and his colleagues, which have at last made it possible to determine in certain cases the responses of single chemoreceptors to a variety of stimulants. The essential unity and interdependence of all research are emphasized by the fact that this work has immediate relevance to at least four other papers in the same volume.

Papers on the chemical control of insects have a depressing tendency to turn into lists of neat little recipes for specific complaints, but the paper by R. E. Balch on "Control of Forest Insects" is an excellent antidote, giving as it does consideration to all the factors—not only chemical—relevant to insect control. Papers on biology and behaviour include two which reiterate the importance of background knowledge in control work: "The Feeding Habits of Biting Flies and their Significance in Classification", by J. A. Downes, and "Hybridization and Speciation in Mosquitoes", by L. E. Rozeboom. It is a little difficult to see the justification for including a paper on the "Biology of Scarabaeidae" (P. O. Richter), a subject so much narrower in scope than any other in the work.

The standard of the papers is high, the presentation good, and the index ample. Uniform bibliographies, in alphabetical order, might be considered as an improvement for the future. This volume is a definite advance on the previous ones in balance and appeal, and without doubt deserves to find a wide and appreciative public.

P. T. HASKELL

UNIVERSITY OF BOMBAY

A History of the University of Bombay, 1857-1957
By S. R. Dongerkery. Pp. vii+313. (Bombay: The University, 1957.) Rs. 15.

THE year 1857 was a sad year for the British administration in India, for the violence of the Sepoy Mutiny imposed a severe strain on Indo-British relationships. It is all the more remarkable, therefore, that at such a time there were men who pressed forward with measures to give form and substance to the concept of higher education in India by founding a university. Indeed, three universities, those of Calcutta, Bombay and Madras, were all founded within a few months of one another; later—on the occasion of the laying of the foundation stone of the University of Bombay in 1863—the Governor of the Province described these foundations as among the last, but not least, glorious deeds of the East India Company.

All the three universities were constituted on the model of the University of London, at that time a chartered body concerned only with examining and conferring degrees upon students trained in affiliated colleges. The defects of the affiliating system were realized later when London was reconstituted in 1900 as a teaching university after two Royal Commissions had reported in 1889 and 1894 respectively.

The corresponding activity in India culminated in the Indian Universities Act of 1904, but controversy there raged loud and long. A Committee on University Reform reporting in 1925 said that except in a loose and indirect sense, prior to 1912, the University of Bombay was not a teaching university, and since that date had only made a very partial approximation to the ideal. The Committee felt that it had been entrusted with the task of suggesting how that approximation could be made more complete.

Then came the Bombay University Act of 1928 which was a great advance and brought the work of the University into direct touch with the leaders of industry and the civic life of a large community. It focused the attention of the University on the conduct of postgraduate teaching and research as a direct responsibility and upon technology.

The reorganization of the Indian Union largely on a linguistic basis has resulted in the emergence of the University of Bombay (1953) as a city university, teaching in federal relationship with its constituent colleges and other recognized institutions. Unfortunately, the battle of the languages is not yet ended, and the future of the medium of instruction has still to be decided. The University has, however, been wise in adopting a cautious approach to this question.

The present volume, which is an extremely readable account of the growth of the University, also marks the centenary of its existence. It has had a chequered history, but it has been fortunate in commanding the devoted service over the years of men of eminence, erudition and foresight. On the whole, perhaps, things have turned out not as well as some hoped and not as bad as others feared.

The author, a versatile scholar intimately connected with the University administration for many years and as the Rector, was clearly well-placed to write this book, and he has provided a pleasing volume giving a fair and full picture of the development of the University and of the dedicated men, both British and Indian, who have shaped its course.

L. A. JORDAN

A School Course of Biology

With Suggestions for Experimental and Field Work. By L. J. F. Brimble. Fourth edition, entirely re-written and enlarged in collaboration with Dr. L. M. J. Kramer. Pp. xv+558. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1957.) 18*s*. net.

THE transformation of a school text-book, which has been in steady demand since 1940, into what is virtually a new volume should endow it with a fresh lease of useful life. It is not a cram manual streamlined to fit the requirements of some examination syllabus: instead, it sets out bravely to present a representative picture of all forms of living matter as they exist now and have originated in the past, and to describe their structure, functions, organization and inter-relationships, including those with man himself.

The chapters on evolution and heredity, living things and their environment, and man in relation to other living organisms are particularly welcome. In these respects the book merits comparison with the attractive readers put out for use in American high schools; and one hopes that some copies will find their way across the Atlantic. For British teaching practice it covers the ground for the General Certificate of Education (Ordinary Level), in many directions extending far beyond it, for it contains a large amount of miscellaneous information on such topics as the speed of animals, the life-history of the eel, parasitic and saprophytic plants.

The treatment is comparative. Directions given at the end of each chapter for individual and class observations and experiments are more than adequate. Among the many well-chosen illustrations, the drawings by the senior author deserve special commendation for their number, clarity and artistic form. The book contains one or two slips in phrasing, and a few minor errors of fact, which merely serve to show that it is impossible for a single author to be fully informed on every topic receiving mention. By the same token, the boys and girls who will study it should not be expected to remember all the knowledge it contains. R. Weatherall

Analytical Microscopy

Its Aims and Methods in Relation to Foods, Water, Spices and Drugs. By Dr. T. E. Wallis. Second edition. Pp. viii+215. (London: J. and A. Churchill, Ltd., 1957.) 25*s*. net.

REVISED for the first time since its publication more than thirty years ago, this book is virtually new, owing to the accumulation of fresh information and the introduction of new methods.

An account is given of the methods of preparing material for microscopical examination and is illustrated by examples selected almost entirely from problems which have arisen during the career of the author. Analytical microscopy, its aims and methods in relation to food, water, spices and drugs, clearly indicates the unequalled experience of an analyst known to many in industry and medicine.

The immensely practical nature of this work is shown by the varied use of the microscope for solving problems which cannot be successfully tackled by purely chemical means.

The introductory chapter deals with general arrangements for the proper use of the microscope and its accessories, followed by a chapter giving details of preliminary operations which are necessary for the examination of foreign matter (including insects) in poultry and bird food. The use of surface preparations is described with reference to the microscopical characters of culinary herbs, and the method of sedimentation is illustrated by investigations of water deposits. The process of kneading is explained in connexion with the analysis of flour and other starchy powders, while other chapters deal with elutriation for preserves and the reagents used for the clarification of specimens. Additional preliminary treatment of material is described by some information on 'crude fibre' in connexion with coffee and chicory. Chemical treatments used prior to the examination of pests, occurring as fragments in flour and other commodities, are mentioned. Chemomicroscopy, the micromorphology of various substances including sulphur, the techniques of sublimation and precipitation—all indicate the extensive scope of this handy volume.

For those wishing to use microscopical measurements, numerical values and quantitative microscopy, the author gives a concise account of the meticulous approach to these subjects. Accurate, well-labelled drawings are a great feature of this book, while valuable numerical data, reagent formulæ and an adequate bibliography complete the store of information available to anyone engaged in analytical work using the microscope. S. B. Challen

The Amphibia of Ceylon

By P. Kirtisinghe. Pp. xiii+112+1 plate. (Colombo: P. Kirtisinghe, 2 Charles Circus, 1957.) n.p.

THE Ceylonese Amphibia are presented here in the form of a taxonomic survey, the general subjects of habits, life-history and ecology being almost completely disregarded. This is a disappointing omission in a book with as definitive a title as "The Amphibia of Ceylon" and in one which would have provided scope for speculative treatment of zoogeography, speciation and other aspects of amphibiology. None of these subjects has been given the attention that is required, perhaps because no research in these fields has been attempted by the author. Instead, Mr. Kirtisinghe has restricted himself to a taxonomic treatment. However, it is a compact and nicely produced book and makes a very useful manual for the museum laboratory worker as well as a reliable field book for the collector.

Preceding the main taxonomic section is a historical account of the study of Ceylonese Amphibia in which the author has collated the faunal lists which have been published by earlier devotees to Ceylon's amphibians. In the light of Mr. Kirtisinghe's experience, which has accrued from his position as lecturer in zoology at the University of Ceylon, from his personal collections and from the year spent in England when he devoted a great deal of time to the study of the Ceylon amphibians in the British Museum collections, he concludes that the composition of Ceylon's amphibians can be reduced from the 37 species recognized by Boulenger to 32, with 12 species believed to be endemic. Although his reasons for synonymizing these and other species may be based on sound judgment, they are not always divulged and the reader is kept guessing.

The same style is adhered to throughout the systematic section—division into families with keys to the genera and species, and within each species account there is, first, a synonymy, followed by a figure and detailed description of the adult, and of the larva also where it is known, and range. The illustrations are well executed by competent artists.

A. G. C. Grandison

SOME EFFECTS OF THE FINE STRUCTURE OF THE IONOSPHERE ON TRANSMISSIONS RECEIVED FROM THE RUSSIAN EARTH SATELLITE 1958δ

By F. A. KITCHEN and W. R. R. JOY
Royal Naval Scientific Service

A SERIES of simultaneous direction-finding and Doppler frequency-shift measurements has been made on the radio transmissions from the Russian satellite 1958δ, on a frequency of 20·005 Mc./s., with the initial object of determining the parameters of local tracks, and hence those of the orbit. As previously discussed[1], these techniques enable the following parameters to be derived, in principle, from observations made during one local transit: velocity, plan and slant ranges (hence the height of the satellite), and bearing of the sub-satellite point at the instant of closest approach (hence track-heading of the satellite at this point). During the course of precise observations on 1958δ, however, some interesting anomalies were observed in the Doppler measurements. These confirmed the existence of similar effects previously noted in the case of observations on 1957α and 1957β, when less-accurate measuring techniques were available. In the system at present in use, all information on bearing, Doppler frequency and time is recorded synchronously on separate channels of a multi-channel tape recorder. An Essen ring quartz-crystal oscillator operating at 100 kc./s. with a frequency drift of less than + 2 parts in 10^{10} per day was used to provide the time reference throughout the system. It was also used to drive a precise frequency synthesizer to generate a local reference signal for comparison with the signal received from the satellite, at radio-frequency. Errors in the frequency measurements originating within the receivers were thus eliminated. Some samples of track parameters deduced for 1958δ are given in Table 1.

One of the anomalies detected in the Doppler observations is a time displacement of the apparent instant of closest approach of the satellite, relative to that deduced from direction-finder observations. Evidence of the reality of this time difference was obtained during revolution No. 71 from south-west to north-east, on May 20, when the normal direction-finding and Doppler frequency-shift observations were supplemented by direction-finding measurements at a remote station about 300 km. distant. Observations from this latter station were recorded synchronously with the results being obtained locally, on the multichannel recording equipment. The times of closest approach to the two stations derived from the simultaneous direction-finding measurements were mutually consistent, and in agreement with the known parameters of the track involved, whereas the corresponding instant deduced from the Doppler observations at Portsdown was 6 sec. earlier than indicated by the associated direction-finder results. This is shown in the graphical transcription reproduced in Fig. 1. The time discrepancy is much greater than would be expected from the inclination of the track relative to the surface of the Earth, particularly since the local track is very near perigee. The phenomenon is considered to be due to the influence of the ionosphere, and it may be explained by refraction of the radiation from the satellite transmitter through part of the *F*-region having a tilted lower boundary, of the type reported by Bramley and Ross[2].

It has been shown[3,4] that refraction of satellite transmissions by the ionosphere will result in a virtual source displaced from the actual source, the displacement increasing with increasing range. In addition to the influence on Doppler records, the effect of this

Table 1. LOCAL TRACK PARAMETERS DEDUCED FOR 1958δ, ASSUMING A FLAT EARTH AND REFERRED TO PORTSDOWN (lat. 01° 06′ 53″ W., long. 50° 51′ 30″ N.)

Date	Revolution No.	Velocity (km./sec.)	Min. plan-range (km.)	Min. slant-range (km.)	Height (km.)	Track heading at closest approach (deg. true)	Inclination of orbit to equator (deg.)
16.5.58	17	8·16	15·8	258	257	040	62
20.5.58	71	8·11	129	318	291	043	64
21.5.58	85	8·12	722	766	290	043	65
22.5.58	98	8·12	230	370	290	040	65

The average period of the orbit between revolutions Nos. 71–98 was 105 min. 53·8 ± 0·1 sec.

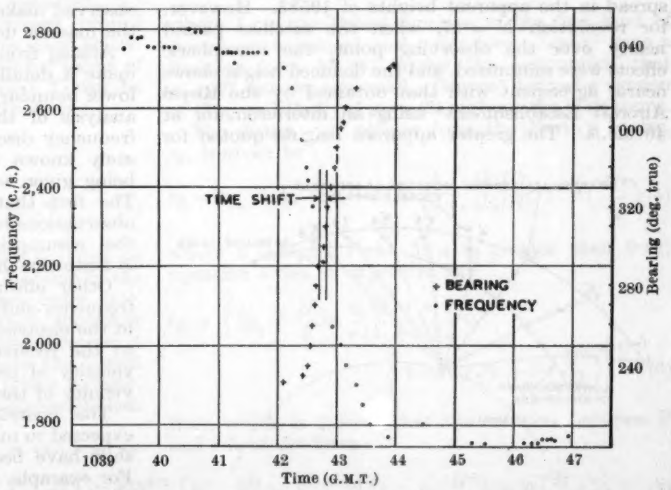

Fig. 1. Time shift in instant of apparent closest approach indicated by simultaneous bearing and Doppler frequency measurements at Portsdown

refraction would also be expected to give rise to associated changes in direction-finding, but the resulting errors will be small in the case of local tracks. In the case where the ionosphere is concentric with the surface of the Earth, the refraction would result in an error in estimation of slant-range from the Doppler measurements, but not in the time of closest approach.

Fig. 2 is a simplified illustration to show how a tilted lower boundary on the $F2$-region of the ionosphere produces the time shift in the instant of closest approach deduced from the Doppler observations. The diagram depicts the case of a satellite moving above a tilted lower boundary of an ionosphere of constant refractive index on a track concentric with the Earth's surface, and over the observing point. The virtual sources are shown, as for example, 2′ corresponding to the true position 2. Again, the effects on Doppler frequency will be expected to be more marked than the corresponding effect on direction-finding observations. In the practical case where the point of observation does not lie in the sub-satellite path, the effects due to refraction will be correspondingly increased.

It is thus expected that refraction by the ionosphere will cause significant errors in the estimation of slant-range and hence height of satellite. Further, that tilts in the lower boundary of the ionosphere will increase these errors, and simultaneously introduce a shift in time of apparent closest approach of several seconds, in a sense depending on the orientation of the lower boundary at that time.

Occasionally time differences of as much as 20 sec. have been measured, in which time the satellite travels a distance comparable to the height and range. It appears unlikely that such large time-shifts are due entirely to ionospheric tilts.

Referring to Table 1, it will be seen that there is a spread in the apparent heights of 1958δ. However, for revolution $N = 17$, when the satellite passed nearly over the observing point, the ionospheric effects were minimized, and the deduced height shows nearer agreement with that obtained by the Royal Aircraft Establishment[5] using an interferometer at 40 Mc./s. The greater apparent heights quoted for

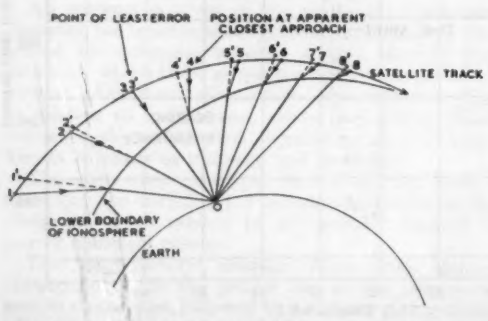

Fig. 2. Effects of refraction in an ionosphere with tilted lower boundary (schematic, not to scale)

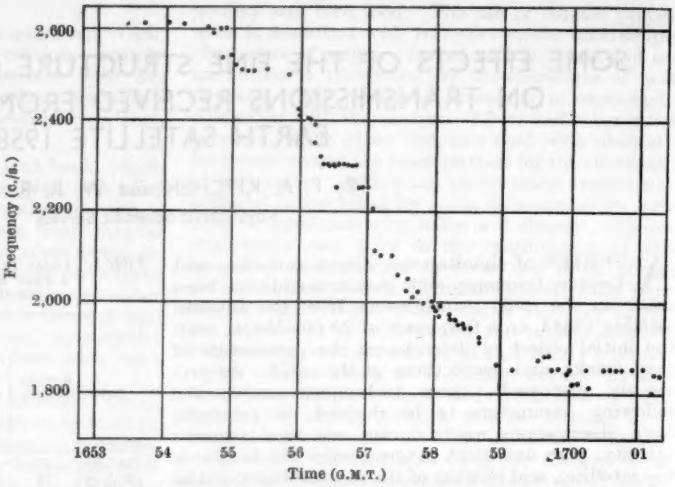

Fig. 3. Examples of discontinuities in a Doppler frequency record

subsequent revolutions are due to variations in the refractive effects described.

Fig. 3 illustrates the marked discontinuities in the Doppler frequency which occur at irregular intervals. This is a typical phenomenon for most of the observations on 1958δ, whether the satellite was approaching or receding from the apex, but was more pronounced in the latter case when the satellite was at greater heights. The magnitudes of the discontinuities in the frequency record are usually too great to be accounted for by alternate reception of ordinary and extra-wave magneto-ionic components of the transmission. It appears more likely that the discontinuities arise from the existence[6] of smaller-scale irregularities in the tilted lower boundary of the F-region, the whole of which is in effective random motion. Similar effects were not observed in the direction-finding bearing records.

It is of interest to note that if the Doppler readings are made sufficiently accurately, and at frequent enough intervals, then in many cases the irregularities observed make it impossible to process the results in the manner described by Hampton[7].

Arising from this work, it appears practicable to make a detailed study of the fine structure of the lower boundary of the F-region of the ionosphere, by analysis of the detailed character of the Doppler frequency discontinuities in conjunction with accurately known orbit parameters. Attention is now being given to this aspect of ionospheric research. The fact that wide variations of direction-finding observations have not occurred in this work leads to the assumption that the influence of sporadic E-ionization has been insignificant.

Other effects of the ionosphere on the Doppler frequency-shift recordings arise due to: (*a*) a change in the electrical length of the path from the satellite to the receiver; (*b*) in general, a change in the velocity of propagation of the radio signals in the vicinity of the satellite.

The contributions these phenomena would be expected to make to the observed Doppler frequency-shift have been estimated, and found to be small. For example, if the satellite is above the maximum of the $F2$-region ionization, the effect of (*a*) is to increase the apparent height by about 9 km. for an

assumed total electron content of 10^{13} per cm. column. When the satellite is in the vicinity of the $F2$-region maximum, the effect of (b) is merely to change the received frequency by not more than a few cycles per sec.

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EFFECT OF AIR DRAG ON THE ORBIT OF THE RUSSIAN EARTH SATELLITE 1957β: COMPARISON OF THEORY AND OBSERVATION

By D. G. KING-HELE and Dr. D. C. M. LESLIE
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IF the orbit of an Earth satellite has an eccentricity greater than about 0·02, most of the air drag is encountered near perigee. Consequently, there is a retardation near perigee and a reduction in height at the next apogee, but very little decrease in perigee height. Thus the orbit contracts and becomes more nearly circular, while the orbital period decreases because the major axis is diminishing.

The equations of motion can be solved analytically if certain simplifying assumptions are made, and the most useful solutions appear to be those obtained under the following assumptions: (1) The Earth and the atmosphere are spherically symmetrical; (2) the density ρ of the atmosphere at a given height is constant from day to day; (3) ρ varies exponentially with distance from the Earth's centre r: ρ is proportional to $\exp(-r/H)$, where H, the 'scale height', is assumed constant; (4) the aerodynamic force acting on the satellite is taken as $\rho v^2 S$ tangential to the path, where v is its velocity and S is a constant which may be interpreted as the effective cross-sectional area of the satellite; (5) the eccentricity e of the orbit is small, so that high powers of e may be ignored; (6) the presence of air drag changes the orbit during any one revolution by only a small amount, the square of which can be neglected.

Under these assumptions, the relevant orbital elements can best be written in the forms given below. If the eccentricity e is sufficiently small for terms of $0(e^3)$ to be neglected, the orbital period T can be expressed as a function of time t in the form:

$$\frac{T}{T_0} = 1 - \frac{3H}{2a_0}\left\{\ln I_1\left(\frac{a_0 e_0}{H}\right) - \ln\sqrt{1-\frac{t}{t_L}}\, I_1\left(\frac{a_0 e_0}{H}\sqrt{1-\frac{t}{t_L}}\right)\right\} + 0(e_0^2) \qquad (1)$$

where a is the semi-major axis, suffix 0 refers to initial conditions, and I_1 is the Bessel function of the first kind of imaginary argument and order one. t_L may, for brevity, be called the life-time, though it is slightly greater than the true life-time, because it gives the time at which T drops not to the lowest practical value (say, 87 min.) but to minus infinity. For *Sputnik* 2, t_L was about 0·6 per cent greater than the true life-time.

Equation 1 has the virtue that it is valid up to the last revolution of the satellite, but for most practical purposes it is preferable to have a formula which includes terms of $0(e^2)$ and avoids Bessel functions. The appropriate form is:

$$\frac{T}{T_0} = 1 - \frac{3}{2}e_0\left(1-\frac{5}{3}e_0\right)\left(1-\sqrt{1-\frac{t}{t_L}}\right) - \frac{17}{8}e_0^2\frac{t}{t_L} + 0(e_0^3) + \frac{3H}{8a_0}\ln\left(1-\frac{t}{t_L}\right) + 0\left(\frac{H^2}{a^2}\right) \qquad (2)$$

The growth of error in (2) as t approaches t_L declares itself plainly, for the term in H/a_0 becomes large, so that the $0(H^2/a^2)$ term can no longer be neglected. By differentiating (2), t_L can be expressed as:

$$t_L = \frac{3}{4}\frac{e_0 T_0}{(-\mathrm{d}T/\mathrm{d}t)_0} \times \left\{1 + \frac{7}{6}e_0 + 0(e_0^2) + \frac{H}{2a_0 e_0} + 0\left(\frac{H^2}{a_0^2 e_0^2}\right)\right\} \qquad (3)$$

When e_0 is very small, say less than 0·02, equation 3 becomes inaccurate, and the appropriate form is that obtained from (1):

$$t_L = \frac{3}{4}\frac{e_0 T_0}{(-\mathrm{d}T/\mathrm{d}t)_0}\frac{I_0(a_0 e_0/H)}{I_1(a_0 e_0/H)} \qquad (4)$$

where I_0 is the Bessel function of the first kind of imaginary argument and order zero. Leslie[1] gave a limiting form of (4), under the assumption that $a_0 e_0/H$ was not too small; Groves[2] derived a version of (3); and Parkyn[3] gave (2) without the $0(e^2)$ terms.

The distance of perigee from the Earth's centre, r_p, is given by:

$$r_p = r_{p_0} + k_0 - k + H\ln\frac{k\, I_1(k/H)}{k_0 I_1(k_0/H)} + 0\left(\frac{H^2}{r_p}\right) \qquad (5)$$

where $k = er_p/(1+e)$. If e is greater than 0·01, equation 5 can be expressed as:

$$r_p = \left\{r_{p_0} - \frac{H}{2}\ln\frac{e_0(1+e)}{e(1+e_0)}\right\} \times \left\{1 + 0(e_0^3) + 0\left(\frac{H^2}{a^2}\right)\right\} \qquad (6)$$

from which it follows that the relation between T and e is of the form:

$$\frac{T}{T_0} = \left(\frac{1-e_0}{1-e}\right)^{3/2}\left\{1 - \frac{3H}{4a_0}\ln\frac{(1+e)e_0}{(1+e_0)e} + 0\left(\frac{H^2}{a^2}\right) + 0\left(\frac{H}{a}e\right)\right\} \qquad (7)$$

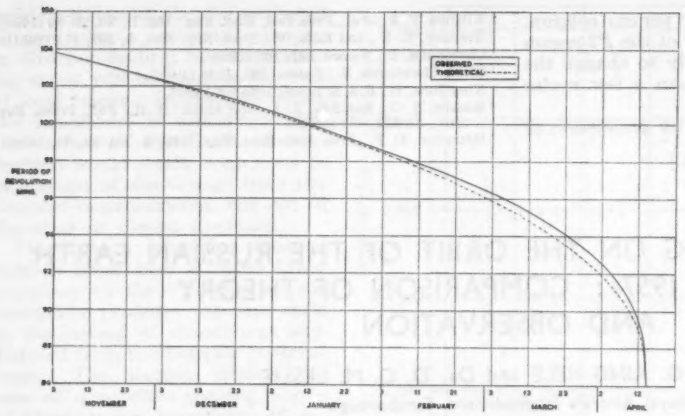

Fig. 1. Period of revolution of *Sputnik* 2 between November 1957 and April 1958. *(Crown copyright reserved)*

Once the initial values e_0 and T_0 are known, equation 7 should provide a good indirect method of finding e. The variation of eccentricity with time is given by:

$$\frac{e}{e_0} = \sqrt{1 - \frac{t}{t_L}}\left[1 - \frac{e_0}{6}\left(1 - \sqrt{1 - \frac{t}{t_L}}\right) + 0(e_0^2) + 0\left\{\frac{H}{a}\ln\left(1 - \frac{t}{t_L}\right)\right\}\right] \quad (8)$$

Equation 8 shows that the variation of e^2 with time is nearly linear, so long as the terms in e_0 and H/a_0 remain small.

The observational values of T and dT/dt for *Sputnik* 2, which are given in Figs. 1 and 2, are based on the analysis of some four hundred observations received at the Royal Aircraft Establishment in the course of the prediction service which was provided from January until April 1958. Most of the observations were accurate to $\pm 1°$ in direction and ± 2 sec. in time, though some were much more accurate. Each observation was used to estimate the time at which the satellite passed through apex, the point of maximum latitude north, and the root-mean-square error in determining apex time was usually not more than about 3 sec. From two apex times approximately a day apart, the mean nodal period of revolution T in the interval could be determined with root-mean-square error usually not more than 0·3 sec., or 1 part in 20,000. The series of values of T was then differenced, at intervals Δt, to give values of $\Delta T/\Delta t$ for comparison with the theoretical dT/dt. The value of $\Delta T/\Delta t$ could be obtained with a root-mean-square error usually not more than $0{\cdot}4/\Delta t$ sec./day, where Δt is in days. Except in the last four days of the life of the satellite, a lower limit of 0·8 day was set for Δt, to avoid large errors. Sometimes, through lack of observations, Δt had to be taken as high as 10 days. It would be possible to produce an improved version of Fig. 2 by determining the apex times more accurately and by a proper

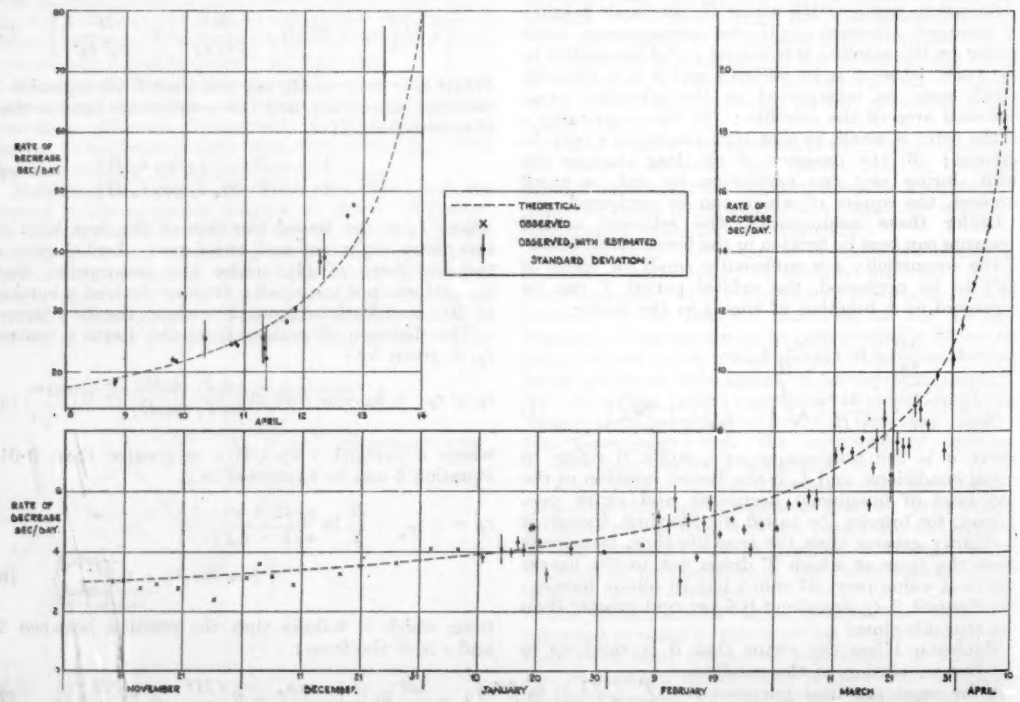

Fig. 2. Rate of change of period for *Sputnik* 2 between November 1957 and April 1958. *(Crown copyright reserved)*

Table 1. ORBITAL DATA FOR *Sputnik* 2 (NOVEMBER 1957–APRIL 1958)

Date (00 hr. G.M.T.)	November 4	January 4	February 21	March 25	April 9	
Orbital period (min.)	103·760	100·505	97·105	93·785	90·780	± 0·005
Semi-major axis (nautical miles)	3,947·1	3,863·7	3,776·1	3,689·9	3,610·7	± 0·2
Eccentricity	0·0987	0·0802	0·0605	0·0400	0·0212	± 0·0006
Perigee distance (nautical miles)	3,557	3,554	3,549	3,542	3,531	± 2
Angle from apex to perigee	− 31°	− 55°	− 76°	− 91°	− 98°	± 1°

Initial inclination of orbital plane to equator, 65·3°. Last column gives root-mean-square errors.

statistical treatment of the results, to decide, for example, the optimum value of Δt. However, the labour required scarcely seems worth while, when independent results from other countries will no doubt soon be available and will show whether there are any spurious values in Fig. 2.

The theoretical curve drawn for comparison in Fig. 1 is that obtained from equation 1, with November 4·0 as initial point, $t_L = 162{\cdot}0$ days and $H = 30$ nautical miles. The agreement between observation and theory is fairly good. But it is by no means perfect, and this is scarcely surprising in view of the irregularities in Fig. 2.

There are two contrasting features of interest in Fig. 2. First, it appears that the theoretical curve provides a reasonable mean value of dT/dt, suggesting that the effective cross-sectional area S underwent no great and irreversible change. This conclusion is consistent with observation, for until April 12 the brightness of the satellite fluctuated widely when it was between the observer and the Sun, and the period of these fluctuations was usually between 1½ and 2 min. These regular changes suggest that, until April 12, the satellite may have been rotating at a roughly constant rate, and that the mode of rotation, for example, a tumble or a barrel roll, may have remained the same. If so, the mean effective area S would be expected to remain constant. The second interesting feature of Fig. 2 is that the observed values depart significantly from the theoretical. Anyone who tried to predict the transits of the satellite will confirm that these oscillations in dT/dt are real, and not due to errors of observation or analysis. Taking theory instead of observation for January 20–February 9, for example, would have led to an error of about ½ hr. in the predicted times. It seems probable that the fluctuations in dT/dt are caused by day-to-day fluctuations in the properties of the atmosphere at perigee, either by changes in the number of particles per unit volume or in their electrical state. Though there is no obvious pattern in the fluctuations of Fig. 2, an oscillation of period about 25 days is faintly discernible, and this has provoked speculation that the tide-raising force of the Moon may play some part. There are many other possible sources for the irregularities, however, and it would be premature to attempt any detailed discussion of them here.

The value of H, the scale height, can in principle be obtained from the orbital data of Table 1, by means of equation 6 or equation 7; but since H depends on the small difference between two large quantities, considerable errors are inevitable. If the initial values are taken as those in the first column of Table 1, and H is determined from (7), using each of the other four columns in turn and giving each equal weight, the value obtained for H is 38 ± 13 nautical miles, almost all the error arising from the error of 0·0006 in e. The errors can be minimized by taking only the last of the four columns. It is then found that $H = 35 \pm 4$ nautical miles from either (6) or (7). Though the error is smaller, the result should still be received sceptically, for several reasons. First, because of the Earth's oblateness the value of H obtained is not the scale height as customarily defined, relative to height above the Earth's surface; when oblateness is taken into account, H is increased by about 25 per cent. Secondly, the irregularities in dT/dt violate one of the assumptions of the theory. Thirdly, H varies with both latitude and height, thus violating two more assumptions. Fourthly, electrical effects may be important and, if so, ρ is not the true air density. For these reasons it is obvious that much further study is required before a reliable value of H can be derived.

We wish to thank the many independent observers who provided the observations for Figs. 1 and 2, and Miss D. M. C. Gilmore, who analysed the observations and prepared the graphs.

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THE BIOGEOGRAPHY OF AUSTRALIA

By PROF. RONALD GOOD
University of Hull

IT has been suggested[1,2] that the biogeographical problems of Australia become less perplexing if it is assumed that Australia and New Guinea, instead of being parts of one and the same primeval land mass, have attained their present proximity in comparatively recent geological times, by some relative movement which has gradually diminished the distance between them. Such a diminution might be caused by an active drift of Australia in an easterly or northerly direction; or to an active drift of the Melanesian–New Zealand arc westwards; or to some combination of these; but at present it is simplest to speak of the drift of Australia towards New Guinea, remembering, nevertheless, that this may be only a relative description.

A theory of this kind must depend largely on circumstantial evidence and the field in which this may be sought is wide, since there is scarcely a cognate science which cannot contribute to it. It seems justifiable, therefore, in order to indicate where this is likely to be most valuable, to suggest in rather more detail, and particularly in botanical terms, one course which events may have taken.

To begin with, plant geographers have long remarked the considerable affinity between the floras of Australia and South Africa, an affinity typified most familiarly by the families Proteaceae and Restionaceae, and by the Ericales, but seen also in many other plant groups. There seems no doubt that this is a true genealogical affinity, and we may therefore postulate that at some earlier period Australia, as we now call it, was much closer to (perhaps actually in contact with) what we now call South Africa, and therefore that its relative movement has been, in general, eastwards.

When, accepting this premiss, we consider the possible direction of movement more closely, an important point at once emerges. If we assume that the drift was directly eastward, then Australia would have remained within the same range of latitude throughout its journey; but if, on the other hand, the drift was to some degree north-eastward, then Australia would, in the course of it, gradually have altered its position in respect of the poles, which for the moment we may regard as retaining their positions. The difference between the two from the botanical point of view is great. In the first case we should expect the original flora of Australia to continue unembarrassed by serious climatic change and to alter no more than might be expected from the prolonged passage of time alone. In the second case, the flora would be under continued and increasing stress through the gradual movement from one climatic condition to another.

In other words, Australia, unless it maintained a true latitudinal course, is likely to have moved so that it came to fall more and more within the warmer and drier conditions of the southern high-pressure belt or horse latitudes, and less and less within the cooler and wetter conditions of the south-temperate low-pressure belt of the roaring forties and north-westerlies. If this movement was considerable, then Australia would even have moved entirely out of one major climatic zone into another.

To-day there are in the Australian flora, in addition to what we may call the basic 'Afro-Australian' element already mentioned, two other great floristic elements, the 'south circumpolar' rain-forest element found now in south-east Australia and particularly in Tasmania (as well as in New Zealand and South America), and the 'Melanesian' rain-forest element of eastern Queensland and north-eastern New South Wales. The presence of the former (of which there is no counterpart in the present South African flora) suggests strongly that Australia was at one time in continuity with a general southern-temperate rain-forest flora and, thus, that its original position was somewhat to the south of Africa and, perhaps, even between that continent and what is now Antarctica. In this position we should expect its flora to consist of two main elements—one in the north having much in common with the nearby South African flora, and a temperate circumpolar element in the south.

From this position we may picture Australia as having drifted at least east-north-east, and it may be almost north-east, and the change in latitude involved as amounting to as much as 20°. Such a move would be likely to cause great floristic changes. In an original position of, let us say, 30° to 60° S., Australia would have lain with only its most northerly portion in a comparatively dry zone and with most of its area in a cooler and much wetter zone. In its present position between 10° and 40° S. it is almost wholly in a dry zone, and only some of its more southerly parts have a wetter and cooler climate. There are, indeed, only two, adjacent, parts of the continent in which rain-forest occurs to-day, namely, the south-east corner with Tasmania, where there is a circumpolar type, and along the warmer east coast, where here and there a more Melanesian type of rain-forest occurs.

Now let us view this supposed drift of Australia from another aspect. At first the movement would have been mainly one of gradual separation from its neighbours, but this would soon amount to a considerable measure of isolation. Moreover, if the relative positions of the other land masses were, and remained, as we know them to-day, then this isolation would not only increase but also would persist for most of the journey, diminishing again only in the later stages as Melanesia was approached. Hence, for much of the time, which may have been a very long period, not only would Australia have been isolated from other lands but also it would have been moving gradually from one climatic zone to another.

In such circumstances it would seem almost inevitable that the flora must have been affected profoundly. On one hand the major area of temperate rain-forest would have become more and more restricted to the south, and on the other, increasingly wide aridity would probably have greatly changed the distribution of the Afro-Australian element. Most important of all, the isolation of Australia from other land masses would have hindered any replenishment of the flora from elsewhere. We should therefore expect that as drift continued the general character of the flora of Australia gradually became changed and probably more drought-resistant, in any event over much of the continent. It may be highly relevant in this connexion that despite the assumption of close prior association with southern Africa, Australia has, unlike South Africa, practically no specialized desert flora to-day, although its arid areas are now at least as extensive. This suggests that at its time of separation from Africa it lacked either the stock from which the African desert flora has or had come, or the appropriate climatic conditions.

Because of these circumstances, a most interesting situation would have arisen as Australia gradually came within population distance of Melanesia. In the first place, it would have arrived in a floristically unsaturated condition ready to be replenished easily at the first opportunity. In the second place, it would have reached a point geographically at which certain local parts of it on the east would have been particularly capable of sustaining tropical rain-forest but of which there would have been no available sources in Australia. It would therefore not be surprising if there was a very rich and rapid invasion of plants from Melanesia as soon as diminishing distance permitted, not only, though perhaps primarily, in the form of rain-forest down the east coast, but also more generally in the form of potentially more drought-resistant elements. Australia may indeed have afforded something like a partial floristic vacuum into which plants from Melanesia would have flowed quickly and easily.

If this was indeed the course of events, we should expect to find, in the present Australian flora, certain prominent features. We should expect to find some remnant of the old temperate rain-forest flora which once covered most of the continent, because the south-east is still as far from the equator as 40° S., and this we see plainly in the flora of much of Tasmania and parts of the adjacent mainland.

We should expect to find in the remaining less-arid parts the general occurrence of the old Afro-Australian flora, and this we do very conspicuously, for it still provides much of the most typical Australian plant life. We should expect a relative absence of specialized desert types because the conditions for their development came after the separation of Australia from areas with such types now, and this, of course, is true. Finally, we should expect to find a strong infiltration of Melanesian types, mostly tropical rain-forest plants, in the north and east wherever the rainfall is sufficient, and the presence of this kind of vegetation in the high rainfall areas of the north-east is familiar and conspicuous.

Hence the sequence of events outlined provides a reasonable explanation of the major features of the present Australian flora without recourse to former land connexions of any kind, except in so far, of course, as the present Torres Straits have almost certainly been dry land on occasion during the very recent geological past, that is to say, on the present hypothesis, since Australia reached New Guinea.

It will be clear now that two very important aspects of the circumstantial evidence mentioned earlier will be the palæontological and the palæoclimatic, and it may therefore be reiterated that according to my hypothesis I should expect the Angiosperm fossil record of much of Australia to show in sequence, first a fairly widespread flora predominantly of a temperate rain-forest kind; secondly, a contraction of this and a spread of an 'Afro-Australian' flora (such as is exemplified by acacias, Proteaceae, Restionaceae, Ericales and various Monocotyledons); thirdly, more widespread evidence of aridity accompanied or closely followed by a great increase in such plants as *Casuarina* and *Eucalyptus*, together with the appearance of some development of tropical rain-forest in the north-east and east; and fourthly, one or more short-term extensions of the more mesophytic kinds of vegetation during the pluvial stages of the Pleistocene.

There is not yet much to guide us in dating these successive phases, but there are one or two pointers. In the larger plant groups, particularly families, there is, with one particular exception to be mentioned, good agreement between the present floras of South Africa and Australia, and it seems clear from this that if the two regions have indeed drifted apart then the process must have begun after the general differentiation of the Angiosperms, that is to say, not earlier than the later Cretaceous or the earliest Tertiary. On the other hand, it may, so far as the plants are concerned, have started at almost any later time, the more recent the start the shorter, of course, being the duration of the movement. Again, whether drift has been going on slowly for a long time or has taken place wholly within a comparatively short time, we do not know. At the nearer end of the time-scale the considerable size of the Melanesian element in the Australian flora to-day (together with the much smaller selection of Australian plants in New Guinea) suggests that an appreciable time has elapsed since these two became close enough together to populate one another, and this in turn may merit the speculation that their approximation was during or at the end of the Pliocene.

On one point the fossil record may be of special importance. The underlying affinity of the floras of South Africa and Australia has been stressed more than once and it should therefore be made plain that there are also puzzling differences between the two. This is notably the case with two of what are now characteristic Australian types, *Casuarina* and the Myrtaceae, especially, of course, *Eucalyptus*. Neither of these is prominent in Africa; the Myrtaceae are very poorly represented there even in the tropics, and *Casuarina* does not occur native at all. Yet both are well-developed and characteristic features of the Melanesian tropical flora. Several species of *Eucalyptus* itself occur there, one of which at least is generally regarded as among the least specialized. May it not be, then, that these two genera, doubtless among others, are not in fact Australian types in origin, despite their prominence there to-day, but among the most conspicuous examples of that filling of a partial vacuum, mentioned earlier, by appropriate stocks from Melanesia?

Finally, it must not be forgotten that the sequence of events outlined above presupposes the present latitudinal distribution of climate, which arises from the position of the poles, to have remained unchanged throughout. To have incorporated the possibility that there was at the same time polar movement would have complicated the picture too much, but it must always be remembered that if, as there seems reason to believe, there may have been some such contemporary changes in the positions of the poles, these could have had one of three effects. They could have intensified the climatic changes suggested; they could have reversed them; or they could even have prevented them. They could scarcely, however, have affected the movement of Australia in itself.

[1] Good, R., *Nature*, **179**, 926 (1957).
[2] Good, R., *Austral. J. Sci.*, **20**, 41 (1957).

OBITUARIES

Dr. Emil Abel

Dr. Emil Abel died in London on April 3 in his eighty-third year, after a short illness. He had studied in Vienna and then under Nernst. In 1905 he established himself as *Privatdozent* at the Technische Hochschule in Vienna, and when a chair of physical chemistry was created he was appointed professor and head of the institute attached to the chair. He held this position until the Anschluss in 1938, when he was dismissed under the Nuremberg laws. With his family he found refuge in England; during the War, and for several years after, until his retirement, he was in charge of the research laboratory of the Ever Ready Co., Ltd.

Though he contributed to many branches of physical chemistry, his main interest was chemical kinetics. His early work was devoted to homogeneous catalysis, and he showed in a series of brilliant papers that the role of the catalyst is the creation of additional reaction paths from the reactants to the products. He used to insist

firmly that "it is reactions that catalyse, not substances".

After the First World War he turned his attention to the reaction complex of the acids and oxides of nitrogen and sulphur, and contributed a number of papers on the mechanism of the reactions in the lead chamber process for the production of sulphuric acid. He also continued his work on the mechanism of oxidation-reduction reactions and studied the isotope effect in kinetics. During the Second World War he worked on industrial problems of national importance and projected a study of the basic mechanism of the dry cell; he worked on this until his retirement. Even afterwards he did not remain idle: he considered different kinetic mechanisms from a unified point of view in which electron transfer reactions play a central part.

Abel had established a large and vigorous school in Vienna, and his institute produced work on many branches of physical chemistry. He had a peculiar, racy style of lecturing, which was appreciated more by the élite than the average student.

He took little active part in matters outside science, but had by no means the narrow outlook of the specialist; those who had the pleasure of hearing his talks to the Austrian Club in London can testify to this. He had an uncomplicated, pleasant nature; though he continued to live in London after the War, he always had a great love for Austria. His eightieth birthday was the occasion for special celebrations by the Academy of Sciences in Vienna and the Bunsengesellschaft.

His two children of his first marriage, and his second wife, survive him. H. Tompa

Dr. J. S. Farquharson

The meteorological service of Great Britain lost a well-known and senior member of its staff, when Dr. James Strachan Farquharson lost his life in a fatal motoring accident on January 31. Dr. Farquharson was born on June 30, 1904, and joined the Meteorological Office in July 1925 after graduation in the University of Aberdeen. He served in various divisions of the Meteorological Office, mainly those concerned with meeting the requirements of civil aviation and the Royal Air Force, both at home and overseas. In June 1954, Dr. Farquharson was appointed as assistant director for public services and, in this capacity, did much to develop both the television and weather broadcasts and the automatic telephone weather service in Britain.

The death of Dr. Farquharson was also a sad loss to the Royal Meteorological Society, of which he had been a Fellow since 1934. As honorary treasurer of the Society, he succeeded in introducing a modification of the old-established policy of investing in gilt-edged securities—a change which he firmly believed will prove of considerable value to the Society. His contributions to the Society's *Quarterly Journal* included two studies related to the development of Empire air routes, namely, "Haboobs and Instability in the Sudan" and "The Diurnal Variation of Wind over Tropical Africa".

The death of Dr. Farquharson has brought to an untimely end an experienced and energetic personality with a wide comprehension of, and original ideas for meeting, the meteorological requirements of the community. R. G. Veryard

Mr. F. J. Welch

The death on May 7 of Mr. F. J. Welch, for forty-six years an assistant in the George Holt Physics Laboratory of the University of Liverpool, has severed one of the few remaining links of personal association with Sir Oliver Lodge, Lyon Jones professor of physics in 1900. Mr. Welch was then only in his early twenties, but his recollections of the great man—and his wireless aerial—were very vivid.

Prof. Wilberforce followed Sir Oliver and held the chair for thirty-five years, and Mr. Welch became senior laboratory steward during this period. Those were the days when popular lectures were delivered on "Liquid Air", and also when medical as well as science students attended lectures and demonstrations in physics, which brought them all into intimate contact, not only with the teaching staff, but also with Mr. Welch, who acted as demonstrator. Many physicists, medical men, dentists and school teachers now scattered all over Britain will have happy recollections of the kind and helpful way he always had with them at these classes.

Sir James Chadwick became professor of physics in 1935, and until he retired in 1946, Mr. Welch was in the Department and experienced the period of secrecy which followed the splitting of the atom; and he had close contact with other well-known physicists, such as Prof. J. Rotblat and Prof. O. R. Frisch.

It is interesting to note that his eldest son, E. A. Welch, who received his early training in the George Holt Physics Department, is now senior technician in the Department of Physics, University College of North Wales, Bangor. W. J. Pierce

Mr. G. A. Cook

Mr. George Alfred Cook died suddenly in Melbourne on January 4. He had enjoyed a comparatively brief retirement from the Commonwealth Scientific and Industrial Research Organization, of which he had been secretary during 1944–52. Before the First World War, Cook was an outstanding student at Ormond College in the University of Melbourne and graduated with first-class honours as master of science and bachelor of mining engineering. During the War he was commissioned in the Second Australian Tunnellers, in which unit he gave distinguished service in France and was awarded the Military Cross.

After the War he spent several years in research work in the mining industry, and in 1922 joined the Institute of Science and Industry as a scientific abstractor. The Institute was replaced by the Council for Scientific and Industrial Research, which in turn was succeeded by the Commonwealth Scientific and Industrial Research Organization, and Cook's service with these bodies was continuous. When he joined the Institute in 1922 there were only two people with scientific training on the staff. When he retired as secretary of the Organization, there was a total staff of more than three thousand, of whom one thousand held professional qualifications. Cook, during his early years with the Organization, took a particular interest in making the results of scientific research available to industry, both as an editor of scientific publications and as a writer of non-technical accounts for the general reader.

NEWS and VIEWS

Sir Macfarlane Burnet, O.M., F.R.S.

THE award of the Order of Merit to Frank Macfarlane Burnet will delight scientific workers generally and particularly those who labour in Burnet's chosen fields of virology and immunology. Australians will, of course, especially appreciate that this high honour has fallen to one of themselves. For most of his life Burnet has worked in Melbourne, at the Walter and Eliza Hall Institute, and he has been its director since 1944. With his increasing scientific distinction he has had many temptations to accept important positions outside Australia. Perhaps he likes Australia; in any event, he has resisted all blandishments and his decision to stay there has been of benefit not only to Australia but, indirectly, to the world at large, for he has founded in Melbourne a school which has attracted many students from distant parts. His contributions to knowledge mostly concern fundamental principles in biology; but others have dealt with problems which have an important Australian aspect to them—*Q*-fever, psittacosis, Murray valley fever and myxomatosis are examples. Burnet is best known for his work on viruses, especially influenza. He and his co-workers have been able to throw important light on the mechanisms whereby viruses become attached to and infect cells. More recently, he has been interested in the nature of antibodies, their mode of formation and of action. Above all, Burnet is an all-round biologist, a master of the 'magnificent generalization'. When men with such rare gifts turn up, they well deserve the highest of honours.

Theoretical Atomic Physics in Copenhagen : Prof. L. Rosenfeld

PROF. LEON ROSENFELD, who has occupied the chair in theoretical physics in the University of Manchester since 1947, is now leaving to become professor in the new Nordik Institute for Theoretical Atomic Physics at Copenhagen. Prof. Rosenfeld is perhaps now most widely known for his contributions to nuclear physics, where his wide interests are well typified by his book, "Nuclear Forces" (1948), which was one of the first authoritative and comprehensive works in the field of nuclear physics, and for his work as editor of *Nuclear Physics*—the first journal devoted entirely to this field. However, his interests have not been limited to this single branch of physics, nor has his influence been confined to Manchester alone. His earlier work with Niels Bohr on the interpretation of quantum mechanics has been followed by many publications dealing with basic problems in physics, their history and their philosophical implications. His views and influence have been made felt in many parts of the world, not only by his published work, but also by his lectures and personal contacts. For Prof. Rosenfeld, physics, and science generally, is part of a mature, scholarly and cultural outlook, an outlook which was conveyed to, and was appreciated by, audiences in many countries. Prof. Rosenfeld's views and ideas were part of the culture of the civilized world, and although the centre from which they are disseminated will now move from Manchester to Copenhagen, their influence will no doubt be as widespread as ever. In Manchester, as elsewhere, one may hope still to continue to enjoy them.

Theoretical Physics in Manchester : Dr. B. H. Flowers

DR. BRIAN H. FLOWERS has been appointed to the chair of theoretical physics in Manchester, from which Prof. Rosenfeld resigns this year. Dr. Flowers took the Natural Science Tripos at Cambridge, and then worked at the Atomic Energy Laboratory in Montreal, and after the Second World War joined the newly established Atomic Energy Research Establishment at Harwell. For a time he worked in Prof. Peierls's Department of Mathematical Physics, University of Birmingham, and was awarded a D.Sc. degree by that University. In 1952 he was appointed, at a remarkably early age, to be head of the Theoretical Physics Division at the Atomic Energy Research Establishment, Harwell, and since then he has continued to occupy this very responsible post. Dr. Flowers is widely known for his many outstanding contributions to the theory of nuclear structure and the application of group-theoretical methods to these problems. In his work at Harwell, Dr. Flowers has contributed to many important problems which have arisen in the extensive range of activities covered by nuclear science and atomic energy. His intellectual gifts, his great energy, his wide experience of physical problems and, through his early work, his first-hand appreciation of the problems of experimental physics, will, in addition to his expert knowledge of nuclear physics, all be greatly appreciated at Manchester. Manchester has a long and distinguished tradition in theoretical physics, a tradition which includes Bohr, Eddington, Hartree, Milne and Schuster, as well as Dr. Flowers's immediate predecessor. Dr. Flowers will, without doubt, further enhance this great tradition.

Dr. J. Glasspoole, I.S.O.

DR. J. GLASSPOOLE, a principal scientific officer in the Meteorological Office and well known to all those requiring information regarding the distribution of rainfall in the British Isles, retired at the end of last year after nearly thirty-eight years service. Dr. Glasspoole began his career in the British Rainfall Organization, which was taken over by the Meteorological Office in 1919. Thereafter he was continuously employed on climatological work, especially the study of one particular element, rainfall. He wrote a large number of papers on the subject and became a recognized authority on the incidence and distribution of rainfall in the British Isles. In recognition of his services, he was appointed a Companion of the Imperial Service Order, and the Institution of Water Engineers made him an honorary member of the Institution.

The Scientific American

IN January 1948, the editing and publishing of *The Scientific American* (415 Madison Avenue, New York, 17), one of the oldest of America's scientific journals (founded in 1845), was taken over by Mr. Gerard Piel and his two partners, Mr. Dennis Flanagan and Mr. Donald H. Miller, jun. At that time, the journal was being far from successful, since only about two thousand copies of each issue were paid for in cash, and advertising revenue was quite negligible. During the past ten years, however, *The Scientific American* has undergone a metamorphosis

which may be described as staggering, for now it has more than two hundred thousand monthly subscribers on its books. Mr. Piel, publisher, and his colleagues are to be congratulated on this great achievement, especially since, through sound policy, good editing and attractive presentation this journal has won the high regard of scientists and laymen alike for its excellent interpretation of scientific discoveries and advancement.

All the articles which appear in *The Scientific American* are authoritative, being written by men of science directly concerned with the work being reported —usually leading authorities themselves. In the past, these have included Einstein, Karl Compton, Robert Oppenheimer and Hans Bethe. But these articles are rigorously edited with the view of clarification, not simplification. The journal is lavish with its illustrations—photographs, drawings, charts and diagrams, many of which are coloured. But the editors make sure that the text shall not become a mere vehicle for attractive pictures. The aim of the latter is to give the reader a vivid grasp of what the article is about and to develop the relationships between variables which so often defy exposition by the written word. So fine, rather than commercial, artists are employed because, as the publisher claims, "The creative artist, when he turns his interest to science, tends to come up with really original solutions to the problems presented by the text".

In connexion with *The Scientific American*, ten paper-backed topical 'anthologies' have also been published, and the aim is to issue about five of these every eighteen months. These 'anthologies' have already been translated into a dozen languages.

Here is a very successful venture into scientific literature for which all scientific workers and especially non-scientific readers must be very grateful. To mark the tenth year of publication under its new direction, a "Cumulative Index" (author, title and subject) of all the issues of this magazine from its first issue (May 1948) to 1957 is now available. We take this opportunity of congratulating the board of editors, including Mr. Gerard Piel (publisher), Mr. Dennis Flanagan (editor) and Mr. Leon Svirsky; the art director, Mr. James Grunbaum; the general manager, Mr. Donald Miller, jun.; and the advertising manager, Mr. Martin M. Davidson, on their magnificent achievement. They are making a first-class and essential contribution to the advancement of science.

Medical Colour Television

On June 4 the first mobile medical colour television unit to be designed and manufactured in Great Britain was handed over by the Marconi's Wireless Telegraph Co., Ltd., to Smith, Kline and French Laboratories, pharmaceutical manufacturers, who ordered the equipment. The vehicle weighs 6 tons, and the television apparatus accounts for a further 2 tons. The available space has been divided into three sections. The rear compartment is staffed by one maintenance engineer to service the apparatus, which combines the red, green and blue signals for transmission via land-line or microwave link. The technical director, the vision mixer, the sound mixer and two camera-control operators work in the centre compartment under the control of the producer. This room houses a colour monitor for each camera, and a third one acts as a line monitor. These are fixed to a monorail, so that they can be moved to either of the other two sections for maintenance or repair. The driver's compartment is also used as a servicing area. The cameras are direct descendants of those supplied to the British Broadcasting Corporation a few years ago. The display unit is a Marconi Colour Television Projection Unit, which can provide a picture 8 ft. × 6 ft., which is said to be adequate for viewing by an audience of up to 300. This equipment will be made available, without charge, to conferences and congresses, so that large audiences can obtain a close-up view of operations or clinical demonstrations. A two-way radio link is provided to facilitate discussion between the surgeon or demonstrator and the audience.

Smoking and Lung Cancer

Following the decision of the Ministry of Health to accept the Medical Research Council's findings as establishing a causal relationship between smoking and lung cancer, local authorities were asked to promote appropriate educational campaigns. The Central Council for Health Education was recommended as a suitable agency. To help local authorities, Dr. John Burton, director of the Central Council for Health Education, has produced a summary of the relevant medical and ethical issues which should be considered by local authorities before launching its campaign. It includes the essential facts about lung cancer; criticism of the facts; other factors involved for which there is some evidence; facts about smoking; reasons for and attitudes to smoking; giving up smoking; policy on presentation of the case against smoking; aims and methods of presenting the facts; and the questions people ask. The summary is a clear, objective, factual account of the relationship between smoking and lung cancer and should give local authorities the kind of lead for which so many of them have been asking.

Language and Speech

Interest in the problems of language and speech has grown rapidly in recent years. In this, the biggest single factor is undoubtedly modern communications engineering and its impact upon the biological sciences. New electro-acoustic techniques have thrown much light on the physical basis of speech and are being increasingly applied to the study of fundamental problems in experimental psychology. The theory of information, as developed by Shannon and others, would appear to have important application to biological systems, not excluding the field of human behaviour. Furthermore, recent developments in statistical technique have given promise of a new and more genuinely scientific approach to linguistics. In view of these considerations, any serious attempt to bring together the many and diverse approaches to the study of speech deserves a warm welcome. *Language and Speech* is a new quarterly edited by Dr. D. B. Fry, of the Department of Phonetics, University College, London (annual subscription: 80*s.*; 11.50 dollars. Single issues: 25*s.*; 4 dollars. Teddington, Middlesex: Robert Draper, Ltd., 1958). Its avowed purpose is ". . . to furnish a medium for publications in which the fundamental problems of speech and language form the centre of interest". It is to offer space not only for reports of experimental findings but also for discussion of theoretical issues arising from, or relevant to, experiment. The fields covered include language structure, the transmission and reception of speech, mechanical translation, synthetic speech, and abnormalities of speech and language. Of particular interest

in the first number (1, Part 1; January–March 1958. Pp. ii+78) is a paper on brain disorders and language analysis by Prof. A. R. Luria, of the University of Moscow.

A Folk-lore Survey

In the *Museums Journal* of May, Mr. J. M. Dodgson describes in detail the procedure adopted in connexion with a survey of English folk-lore which he is carrying out from University College, London. The object of the survey is a classified index of English folk-traditions, comparable with that of Swedish folk-lore in Sweden or of Irish and Scottish folk-lore in Dublin and Edinburgh. The survey is being conducted in a scholarly and critical manner and is an attempt to reduce to methodical order a subject which up to the present has not been dealt with on a scientific basis. The co-operation of museum curators is invited, and Mr. Dodgson looks forward to the time when every district of England will possess a well-ordered folk museum.

Federation of British Industries

The forty-first annual report of the Federation of British Industries, covering the year ended December 31, 1957 (pp. vi+43. London: Federation of British Industries, 1958), displays the wide range of the Federation's interests. During 1957 the Federation continued to be greatly interested in the problems involved in Britain's possible entry into a European Free Trade Area, and its studies of the implications of this proposal led to a general survey for industrialists and a joint report, with the Association of British Chemical Manufacturerr and the National Union of Manufacturers, to the Government on the kind of convention it should seek in the negotiations for a Free Trade Area, and a study of comparative taxation in European countries. In November the Grand Council of the Federation finally recorded its opinion as being, on balance, in favour of the Government's policy, provided certain safeguards and conditions were secured. Evidence was submitted to the Radcliffe Committee inquiring into the working of the monetary and credit system, and to the Trade Effluents Sub-Committee of the Central Advisory Water Committee, which is considering the law affecting the disposal from trade premises of liquid effluents; much statistical information was collected for another sub-committee considering the growing demands for water, and the Federation pioneered a scheme whereby the Department of Scientific and Industrial Research will undertake, on behalf of industry, research on the fundamental problems of the treatment and disposal of trade wastes and the purity of rivers. In education, links with the universities, technical colleges and schools were further consolidated, and a memorandum submitted to the Minister of Education in August supported particularly the proposal of the Willis Jackson Committee for a staff college for senior teaching staffs in technical colleges. Among topics considered by the Industrial Research Committee were the establishment of a National Lending Library for Science and Technology and British official overseas scientific representation.

Scaling-up of Chemical Plant

The Institution of Chemical Engineers, in co-operation with the Chemical Engineering Group of the Society for Chemical Industry and two similar Dutch organizations, arranged a two-day symposium in London in May 1957 on "The Scaling-up of Chemical Plant and Processes". Previously, the literature on the subject had been very scanty, but the recent text-book by Johnstone and Thring (see *Nature*, 181, 1094; 1958) and the proceedings of the symposium (pp. 136. London: Institution of Chemical Engineers, 1958. 60*s*.) together form a sound basis for a study of the subject. One of the major decisions to be taken in developing a new process is whether or not to carry out pilot-plant tests and how best to interpret the information so obtained. The papers presented at the symposium cover a wide field and illustrate many of the problems involved. The first session was devoted to fundamental aspects: introductory ideas on scaling-up and the principles of similarity are discussed, together with the design of reactors, with special reference to the economics of batch, tubular and continuously stirred tank reactors. The first session ended with a discussion on the relation between the cost and the size of plant. The following three sessions were devoted to scaling problems related to specific processes and equipment, including the rotating-disk contactor, cyclones, air-separation plant, continuous-filtration equipment, and solvent extraction and gas absorption. The discussion at the end of each session is also reported. About 60 per cent of the papers were from England and 40 per cent from Holland.

Pharmacopœias, Dispensatories and Formularies

Human societies, as it seems, have long had an inherent urge towards the possession of a *materia medica*. In this connexion, the biological journal, *Lloydia* (20, 1; 1957. Lloyd Library and Museum, Cincinnati, Ohio), contains an article of somewhat unusual interest, namely, "A Catalogue of the Pharmacopœias, Dispensatories, Formularies, and Allied Publications (1493–1957) in Lloyd Library". As the authors explain, John Uri Lloyd, who founded the library in 1864, began to collect these literary materials in the same year. This effort has evidently been continued with zeal, so that the collection now contains more than 1,000 titles, dating from 1493 to the present time, from all parts of the world. The arrangement of the catalogue is alphabetical by countries and chronological by dates of publication. Among the illustrations, one may note reproductions of the title pages of such works as "Pharmacopœa Dogmaticorum Restituta" (Paris, 1607) and "Pharmacopœa Persica" (Paris, 1681).

Metabolism of Marine Flagellates

The products of photosynthesis of two marine flagellates have been examined and compared with those of *Chlorella pyrenoidosa* with the use of radioactive carbon and chromatographic techniques by R. G. S. Bidwell (*Canad. J. Bot.*, 35, 945; 1957). The alcohol-soluble products were different in each alga, many of the compounds produced by the marine forms being unidentified. The principal soluble product of photosynthesis of a member of the Heterokontae, *Olisthodiscus* sp., was identified as *d*-mannitol. Those of a dinoflagellate, *Amphidinium carteri*, include glycosides of glucose and mannitol. The main insoluble carbohydrate produced by all three organisms gave rise to glucose on hydrolysis; this only contained about 10 per cent of the total fixed carbon. The radioactive compounds released from the alcohol-insoluble residues by acid hydrolysis were similar in the three algae and consisted mainly of amino-acids.

Electron Density Profiles in the Ionosphere

In many parts of the world during the past twenty years, regular measurements have been made of the maximum electron density (N_m) and the approximate true height (h_m) of the various layers in the ionosphere. Both these parameters can be obtained fairly easily from the $h'(f)$ curves (ionograms) which are produced by automatic pulse-sounding equipment. On the other hand, very little accurate information is available on $N(h)$ profiles, the distribution of electron density with height in the ionosphere, and how these profiles vary with time, season and geographical location. Correspondingly, little is known about the variation of electron density with time at a constant height (the $N(t)$ curve). The ionograms contain all this information, but the mathematical procedure for deriving it explicitly is very laborious, especially if the effect of the geomagnetic field is taken into account. The electronic computers now available have opened up a new era in this field since they can readily be used to compute $N(h)$ profiles from ionograms.

A programme of such computations has been organized by the Radio Research Station of the Department of Scientific and Industrial Research, at Slough, as part of the United Kingdom programme of observations during the International Geophysical Year. The $N(h)$ profiles are being produced by Ferranti, Ltd., on a "Pegasus" automatic digital computer using $h'(f)$ data obtained at four observatories, namely, Slough, Ibadan, Singapore, and Port Stanley. For each observatory profiles are being calculated for each hour of the day for about four days a month beginning in July 1957. When the ionograms are suitable, Regular World Days are selected for analysis; when this is not practicable, other days are substituted. This programme will be continued until December 1958 when the possibility of extending the work will be considered. The analysis is carried out according to a method recently described by Thomas, Haselgrove and Robbins (*J. Atmos. Terr. Phys.*, **13**, 46; 1958), which makes no *a priori* assumptions about the variation of electron density with height except that it increases monotonically. It can be applied to $h'(f)$ curves from any observatory merely by changing the geomagnetic dip angle and the gyro-frequency, both of which are taken into account in the calculations.

The Association of Universities of the British Commonwealth

The report for 1956–57 of the Executive Council of the Association of Universities of the British Commonwealth (pp. 25. London, 1958), to which are appended a note on the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom (which met eleven times during the year) and the accounts of the Association, records expenditure of £24,797 and an income of only £26,980 compared with £27,860 for 1955–56. Lists of names and other particulars of overseas students continued to be collected from all universities and university colleges in the United Kingdom and a statistical analysis of this material has been printed as an appendix to the Commonwealth Universities Year Book for 1958. These lists are available for consultation by accredited inquirers and the Association also maintains a collection of up-to-date issues of official publications of Commonwealth universities, which are available in the office for reference by inquirers. During the year the Association acted in connexion with 408 appointments in member universities outside the United Kingdom, compared with 394 in 1955–56, and handled 2,871 inquiries in relation to specific vacancies, compared with 2,962 in 1955–56. A list of posts in respect of which the Association was requested to take action is included. The Association has also assisted in the administration of the Marshall Scholarships, the Beaverbrook Scholarships, the Commonwealth University Interchange and in the award of British Memorial Scholarships for study in Australia and Imperial Relations Trust Fellowships.

European Interchange Scheme for Postgraduate Students

The Department of Scientific and Industrial Research is encouraging the interchange of research students between the United Kingdom and certain European countries, and has set aside a number of its research studentships for this purpose. Those awarded such studentships for study in Europe will receive maintenance allowances, second-class rail fare and fees; in addition, a cost-of-living allowance will be paid for certain countries. The award is tax-free. The duration of the award, and other conditions, are the same as those for ordinary Department of Scientific and Industrial Research studentships. Applications for these awards must be made through heads of departments of science and technology in universities and colleges before July 1.

Grants to Students

The National Union of Students has published a Grants Year Book (pp. 107. London: National Union of Students, 1958. 3*s*.) giving details of awards to students by nearly all the local education authorities of Great Britain. Besides information about the scale of awards, allowances for vacations and dependants, the book also provides details of how awards are made, the policies of local education authorities to students who fail examinations and other relevant items. A copy of the Ministry of Education Regulations for State Scholarships is also included; this sets out the income scale for assessing parental contributions. The book should be of practical value to all students and their parents or guardians.

The Salters' Institute of Industrial Chemistry

The Worshipful Company of Salters, through its Institute of Industrial Chemistry, has since the foundation of the Institute in 1918 devoted its resources mainly to the award of postgraduate research grants. Ninety-eight research students have been awarded fellowships and most of them have had distinguished careers in industry and the universities. In 1951 the award of a research scholarship was instituted, and twenty-eight students have since been elected, including three to scholarships reserved for students from the Commonwealth. A considerable number of smaller grants have also been awarded each year to part-time students of chemistry in London, and many of the chemical engineering departments of universities throughout Britain have received substantial grants for the purchase of equipment or similar purposes. Arrangements have now been made with the Royal Institution for the Company to sponsor lectures to school-children in some of the interesting branches of chemistry, on the lines of the lectures on

physics which have been given there with such success in recent years. The Institute has also decided to make grants to headmasters of selected public schools from which Salters' Exhibitions may be awarded to able boys who might otherwise be unable to complete a scientific education. By these new developments, the Institute hopes that the study of science in schools may be enlivened and encouraged and that indirectly the flow of scientists of high calibre to the universities and eventually to industry and other fields may be increased.

Royal Netherlands Geographical Society : Honorary Members

THE following have been elected to honorary membership of the Royal Netherlands Geographical Society: Prof. J. Büdel, University of Würzberg, distinguished for his researches on peri-glacial phenomena and on the morphology of the humid tropics; Prof. H. C. Darby, University of London, author of "A Historical Geography of England" and "Medieval Fenland and the Draining of the Fens"; G. J. A. Mulder, Netherlands, author of various text-books on geography including "Geography of the Mediterranean Region" and editor-in-chief of the "Manual of Geography of the Netherlands".

The Manchester Literary and Philosophical Society: Officers

AT the recent annual general meeting of the Manchester Literary and Philosophical Society the following officers were elected: *President*, Mr. C. E. Young; *Vice-Presidents*, Miss A. C. Alexander, Mr. A. H. Goulty, Sir Geoffrey Jefferson, Dr. F. C. Toy; *Hon. Secretaries*, Dr. G. T. Ashley, Dr. L. Cohen; *Hon. Treasurer*, Mr. H. Hayhurst; *Hon. Librarians*, Mr. L. L. Ardern, Dr. W. H. Brindley; *Hon. Curator*, Mr. N. G. C. Pearson.

The Night Sky in July

FULL moon occurs on July 1d. 06h. 04m. U.T., new moon on July 16d. 18h. 33m. and full moon on July 30d. 16h. 47m. The following conjunctions with the Moon take place: July 9d. 15h., Mars 3° S.; July 14d. 06h., Venus 3° N.; July 23d. 04h., Jupiter 2° N.; July 27d. 03h., Saturn 3° S. In addition to these conjunctions with the Moon, Mercury is in conjunction with Pollux on July 1d. 11h., Mercury being 4·9° S., Venus with Aldebaran on July 5d. 06h., Venus being 4·0° N., and Mercury with Regulus on July 26d. 05h., Mercury being 1·6° S. Mercury is an evening star, setting about an hour after the Sun, but conditions are not favourable for observation. Venus is a morning star, visible low in the south-east before sunrise. It rises at 1h. 55m., 1h. 50m. and 2h. 10m. on July 1, 15 and 31, respectively; its stellar magnitude is −3·3. During the month its distance from the Earth increases from 120 to 137 million miles and the visible portion of the apparent disk from 0·812 to 0·890. Mars rises at 0h. 10m., 23h. 30m. and 22h. 50m. at the beginning, middle and end of the month, respectively; conditions for observation are rapidly becoming more favourable. Its stellar magnitude increases during the month from +0·3 to −0·1, its distance from the Earth decreasing from 101 to 86 million miles. Mars continues to move eastwards among the stars, passing from Pisces to Aries on July 26. Jupiter sets at 0h. 10m., 23h. 15m. and 22h. 10m. on July 1, 15 and 31, respectively; it is near Spica. The stellar magnitude of Jupiter is −1·6, its distance from the Earth on July 15 being 500 million miles. Saturn sets at 2h. 45m., 1h. 45m. and 0h. 35m. at the beginning, middle and end of the month, respectively; it is near θ Ophiuchi. It has a stellar magnitude of +0·4 and a distance of 850 million miles from the Earth on July 15. There is one occultation of a star brighter than magnitude 6 visible at Greenwich: July 24d. 21h. 05·8m., ν Lib. (disappearance). The Earth is at aphelion on July 5, its distance from the Sun being 94·6 million miles.

Announcements

THE British Overseas Mining Association Educational Trust has been established by the Association to provide scholarships tenable at mining schools and universities in the United Kingdom for courses in mining engineering and related subjects. Further information can be obtained from the Secretary of the Association, 8 Great Winchester Street, London, E.C.2.

THE Oliver Memorial Fund is offering an award of £50 to a British subject for original work or services in connexion with the research, organization or donor aspects of blood transfusion. Applications or information on possible candidates for the award should be sent to the honorary secretary, Mrs. F. E. Bedborough, 105 New Park Avenue, London, N.13.

THE thirteenth annual exhibition and convention organized by the Northern Division of the Institution of Electronics will be held at the Manchester College of Science and Technology during July 10–16 (excluding Sunday, July 13). It will include the largest British display of electronic devices held outside London.

A ONE-DAY meeting of the Polarographic Society will be held at Ardeer, Ayrshire, on September 26, by kind permission of Imperial Chemical Industries, Ltd. Further information can be obtained from Mr. A. F. Williams, Research Department, Imperial Chemical Industries, Ltd., Nobel Division, Stevenston, Ayrshire.

A CONFERENCE on Mass Spectrometry is being organized by the Mass Spectrometry Panel of the Institute of Petroleum Hydrocarbon Research Group and Committee *E*-14 of the American Society for Testing Materials. It will be held in the Beveridge Hall, Senate House, University of London, Gower Street, London, W.C.1, during September 24–26. Further information can be obtained from Dr. R. R. Gordon, National Coal Board, Coal Research Establishment, Stoke Orchard, Cheltenham, Gloucestershire.

THE seventh Conference on Hot Laboratories and Equipment is to be held in Cleveland, Ohio, during April 1959. Abstracts of papers to be presented at the Conference should be sent to the programme chairman, L. G. Stang, jun., Brookhaven National Laboratory, Upton, New York, before September 15. Papers are invited on all phases of hot laboratories and equipment for handling radioactive material, including design, construction, operation, maintenance, decontamination, remodelling, shielding calculations, costs, etc.

ERRATUM. In the communication entitled "Passage of Phosphate through the Human Tooth", by Dr. P. Pincus, in *Nature* of March 22, p. 844, paragraphs 5 and 6, for "inorganic phosphate" and "inorganic form" read "organic phosphate" and "organic form".

INDUSTRIAL PSYCHOLOGY

AN outline of the history and work of the Medical Research Council's Industrial Psychology Research Group, since its origin (under another name) in 1918, has recently been provided by R. Marriott, assistant director of the Group (*Occupational Psychology*, 32, No. 1; January 1958).

Between 1918 and 1947 more than a hundred reports and many papers were published. Broadly speaking, the wide range of subjects covered could be classified under the general headings of environmental conditions (lighting, vision, heating and ventilation), the effect of industrial solvents, industrial disease, sickness and absence, hours of work, repetitive work, human relations, vocational psychology, time and motion study, accidents, skill and machine design.

After the Second World War it was decided to bring the existing teams into line with other units or groups of the Medical Research Council by making them self-contained and directly responsible to the Council for their activities. Two of these teams had been mainly responsible for most of the psychological investigations. One, the Applied Psychology Unit at Cambridge, had done much work on accidents, environmental conditions, skill and machine design. The other team, under the direction of Dr. S. Wyatt, had been mostly concerned with such problems as absence from work, motivation and incentives, interest and boredom in work, and satisfaction and discontent in the working situation. This team became the Industrial Psychology Research Group with Dr. Wyatt as its first director. In 1952 the Group was transferred to University College, London, under the honorary direction of Prof. R. W. Russell and Mr. J. W. Whitfield, of the Department of Psychology.

During 1946–52 the Group's two teams, with from four to six investigators in each, were mostly occupied with comparative studies of the nature, extent and causes of satisfaction and discontent in various types of large industrial organizations. The published papers show, for example, clear-cut relationships between working efficiency and size of group and between satisfaction and size of group. They also demonstrate that workers' satisfaction is correlated with the amount of mechanization in the layout. Thus, those on mechanized layouts are less satisfied and express more boredom than those on non-conveyor-line work; individual workers are the most satisfied and least bored. Satisfaction with earnings was related to family responsibilities, and general satisfaction to various factors such as hours of work, shift systems and management policy.

Since 1953 most of the research done by the Group has been concerned with three general problems—absence in heavy industry, communication within industrial firms, and incentive payment systems. Final reports on these projects have not yet been published, but some papers and abstracts bearing on the investigations are available. The following are brief outlines of the methods used and the main conclusions.

A survey was made of the absences of three thousand men in one engineering and two large iron and steel works. Absence from all causes was compared for such factors as age, family responsibilities, length of service, wages, hours of work and physical conditions.

It was found, in general, that absence was least from men with two dependants and higher for those with fewer or more—the curve was U-shaped; higher paid men lost more time due mainly to sickness but partly to absence without permission; absence was associated with heaviness of work, the trend being more pronounced for short absences and among men on continuous work. Continuous work also appeared to cause more absence among men more than forty-five years of age; on three-shift systems about three-quarters of the absence without permission occurred on the early morning shift, due, it was thought, to the 6 a.m. start.

Three studies were made under the heading of communication in industry, one in the laboratory and two in factories.

The experimental study sought to compare the relative understanding and retention of salient points in a prose passage (uncompressed information) and in a précis of it (compressed information). Pilot studies showed that recall, not recognition, of the material was the most successful method of discriminating between the two kinds of information.

Studies in four engineering firms were made, by interviews, observation and the analysis of records, of the differences in formal communication structures in planning and production control, and in particular of their effects on the estimating of delivery dates to customer firms. Differences between the firms in these respects were mainly in the degree of integration between planning and control. On this depends the adequacy and accuracy of the estimator's knowledge of the results of his decisions. It was found that more accurate estimates were made and greater satisfaction was expressed where there was unity of planning and control; the opposite was true where these two functions were divided.

Another inquiry showed that, in general, delivery time was twice as long as the time allowed for production; only 2 per cent of the orders took less than the expected time; 80 per cent of the delay occurred during normal production and 20 per cent in rectification work. The 80 per cent normal production delay was analysed as 9 per cent in supplying materials, 9 per cent in routing between departments, 30 per cent in a capacity block in one department, 15 per cent in the planning and pre-production departments and 17 per cent in other production departments.

Though the analysis of the results is still incomplete, it can be stated tentatively that production control failure, not technical breakdown, was mainly responsible for the total delay.

Recent research into incentive payment systems has taken the form of four separate studies which, although conceived as parts of the whole, were carried out to a large extent independently of each other, as well as a review of research and opinion on incentive payment systems.

Two of these studies were general field surveys relating to workers' understanding of incentive payment systems and to the aims associated with the introduction of such systems. The other two

studies concerned the effects of changes in incentive payment systems in a factory and a repair works. All the studies showed the importance of considering the total factory situation, the relevance of the incentive payment system to the nature and organization of the work, and the social effects produced by these systems.

Satisfaction with a system appeared to be related to the understanding of it, and this depended on the workers' ability to explain it to themselves.

In the two studies of changes in payment systems it was found that improved morale and satisfaction followed the change, but it was not possible to attribute this to the alteration alone. There was evidence that improved output may accompany increased satisfaction, but different performances by comparable working groups were attributed more to the size and stability of the groups. Social conflicts arose in group systems if there was equal regard for unequal effort.

In addition to these investigations, essential incidental studies have been carried out on methodological problems in order to facilitate work in this field. Among these are a study of the dangers of using crude absence-rates available in industry; examinations of the use of linear and verbal self-assessment scales in the assessment of attitude; consideration of possible extensions of the paired comparison technique in measurement of opinion and in measurement of agreement of opinion; a study of the different methods of measuring understanding and remembering of verbal material and the development of rank correlation methods.

Papers have also been published on accidents in industry, and on the effects on skill and performance of machine design, environment and technological change.

CONTACT STRESSES

So many engineering devices, such as toothed gears, rolling bearings and the wheel itself, operate by the transmission of large forces between surfaces in contact over a relatively small area that a knowledge of the local stresses set up in the region of such contacts is obviously of wide interest. Yet the symposium, organized by the Stress Analysis Group and held at the Institute of Physics on May 14, appears to have been the first in Britain to be devoted specifically to the topic of "Contact Stresses". An explanation for the neglect of the subject probably lies in the mathematical difficulties involved in obtaining a theoretical solution to even the simplest problem in contact stress. Apart from the inspired, and now classical, theory of elastic contact presented by Hertz in 1881, there have been until recently very few contributions to the theoretical structure of the subject so beloved of academic investigators. In consequence, the engineering designer has been obliged to develop his own empirical rules and to conduct his own comparative tests to avoid the undesirable consequences of excessive contact stresses: pitting, scuffing, fretting or simple wear.

The past few years, however, have seen considerable advances in the theory of contact stresses. A number of solutions have been found, arising, as so often is the case, from investigations in other fields, to the problem of contact of both ideally elastic and ideally plastic solids under the action of various systems of forces. The basis for more fundamental and revealing studies of the mechanism of surface breakdown under contact loads appears to have been laid, and it is likely that more satisfactory explanations of pitting and other surface failures are not too remote. Even the study of metallic friction and wear, which has attracted scientific work of high quality over a number of years, has benefited from recent theoretical studies.

The present symposium gave encouraging evidence of this trend. The extent to which the problems are common ones was striking. Speakers whose papers arose from interests as diverse as railways, toothed gearing, ball-bearings and rubber tyres described phenomena which were basically similar and to which the academic contributions were relevant.

Contact-stress problems can be divided broadly into two categories, one of contact between surfaces having no relative movement, and the other to include contact between rolling or sliding solids. The first session was devoted to stationary contact, and naturally the papers were concerned with various extensions to the Hertz problem of two ideally elastic bodies under the action of a purely normal force. Mr. C. Storey (Constructors—John Brown, Ltd., Leatherhead) recalled Hertz's assumption that the undeformed profile of the solids in contact could be taken to be parabolic, and showed how the theory could be improved for spherical surfaces. The correction appears to be significant only where there is close conformity between the surfaces, as for a ball-ended pivot in a spherical seating.

Perhaps the most valuable recent contribution to elastic contact theory is due to Mindlin[1] and his associates, who have found the surface tractions and displacements at a contact where a tangential force and a twisting couple are applied in addition to a normal force. They have shown that in consequence some slip is inevitable at a periphery of the contact area. Explicit calculations of the internal stresses in these circumstances have not been made, so that the experimental work of Mr. E. Ollerton (Nottingham) is particularly valuable. He described a photoelastic investigation of the contact stress-field under the action of a normal and tangential force (less than the limiting friction force). The observations with a two-dimensional model as the tangential force approached its limiting value were shown to compare favourably with the theoretical analysis of Poritsky[2]. With smaller tangential forces and also with a three-dimensional model, an attempt was made to deduce the surface stresses to compare with Mindlin's theory, but at the present stage of development of the technique the comparison is rather inconclusive.

The work of Bowden and Tabor[3] on metallic friction has shown that the intimate contact of metal surfaces is to a large extent a plastic phenomenon. In the most lightly loaded contacts the surface asperities are crushed plastically so that the subsequent application of a tangential force, however small, must cause further plastic flow. Dr. D. Tabor

(Cambridge) discussed this process, referring to the experiments on adhesion carried out by McFarlane and Tabor[4] and to the measurements of initial tangential displacement by Courtney-Pratt and Eisner[5]. In both these investigations the behaviour of a single asperity was simulated by using small, heavily loaded contacts in soft metals so that their real and apparent areas of contact coincided. The application of a tangential force to a contact already stressed to the yield pressure in compression causes an immediate increase in the area of real contact. The predominant plastic deformation, therefore, initially brings the surfaces closer together, while the tangential displacements are of an elastic order of magnitude, as their agreement with Mindlin's elastic theory shows. As the tangential force is increased, the contact undergoes large, irreversible, plastic deformation in the tangential direction until, at a point determined by the cleanliness of the surfaces, the junction breaks, and complete sliding occurs. In the context of a meeting on contact stresses it is relevant to ask how the essentially plastic behaviour of individual surface asperities can be related to the overall properties of a contact in which the forces are transmitted through a large number of asperities, while the main body of the material is stressed within its elastic limit—the usual situation found in engineering practice. Is an elastic theory of any value? The experiments of Johnson[6] suggest that the deformation of the contact as a whole can be predicted very closely by an elastic theory. The explanation seems to lie in the fact that if contact is maintained through a large number of junctions their tangential plastic deformation is 'controlled' (in the sense used in plasticity theory) by the strains in the hinterland which remain elastic. Thus two solids first pressed into apparently elastic contact and then sheared undergo normal and tangential displacements given by Mindlin's theory. Over the central area of contact, where the normal pressure is high and the tangential tractions low, the solids are locked together. Towards the edges of the contact area, where Mindlin predicted slip, the asperities may be expected to shear plastically in the manner of Courtney-Pratt's model, through a displacement sufficient (yet no more than sufficient) to relieve otherwise infinite elastic stresses in the body of the material.

The second session was devoted to papers on rolling contact. Experimental investigations of the tangential stresses and relative movements at the contact surface of a rolling pneumatic tyre were reviewed by Mr. V. E. Gough (Dunlop Rubber Co., Ltd., Birmingham). The importance of tangential surface stresses was emphasized since these provide both the driving force and also the controlling forces of a wheeled vehicle. The amount of slip between the tyre and the ground determines the wear-life of the tyre. It was shown that the area of contact is divided into two regions: a forward region where there is no relative movement with the ground, and a region at the sides and trailing edge of the contact area where slip occurs. If the plane of the wheel is inclined at an angle to the direction of rolling, which would arise from the side-slip when rounding a corner, the tangential tractions at the contact surface provide a transverse 'cornering' force. In addition, due to the fact that the slip occurs at the rear of the contact area, this force exerts a self-aligning torque tending to rotate the plane of the wheel into the direction of rolling. Measurements of the cornering force and self-aligning torque as a function of the slip (or yaw) angle show that these quantities increase in proportion to the slip for small angles to a maximum value, after which they decrease gradually. The maximum value corresponds to the transition from partial slip to complete sliding of the tyre on the ground.

The similarity in behaviour of a rolling tyre and a rolling solid is striking. In a later paper, Dr. K. L. Johnson (Cambridge) showed pictures of the contact area of a solid rubber ball rolling on a 'Perspex' sheet. The patterns of slip are almost identical: slip begins at the sides and trailing edge and spreads forwards as the tangential tractions are increased. Experiments with steel balls rolling on steel tracks exhibit similar relationships between the slip motion, or 'creep' as it is frequently called, and the tangential forces and twisting moments. Conditions similar to those obtaining in the case of a tyre rounding a corner occur in angular-contact ball-bearings, where, due to rolling around a curved track, the balls have an angular velocity of 'spin' relative to the races on which they roll, and tangential forces are brought into play by virtue of the 'creep' motion. It follows that in such a bearing the steady-state rolling path of the balls lies between surfaces of the races which are not parallel at the two points of contact, a result which is contrary to the usual assumption in ball-bearing design.

Messrs. A. A. Milne and A. M. Nicholson (Mechanical Engineering Research Laboratory, Glasgow) and also Dr. A. W. Crook (Associated Electrical Industries, Ltd., Aldermaston) were indirectly interested in the life of rolling contacts—the former in rolling bearings and the latter in toothed gears—so that their papers dealt with the breakdown of the rolling surfaces under the continuous application of heavy loads. Milne and Nicholson described some experiments using a modified four-ball machine[7] in which a single rotating ball rolls on three others. The kinematics of the motion were analysed and it was shown that there is a large angular velocity of spin between the rotating and the rolling balls, in consequence of which slip occurs at the sides of the contact area. The majority of the pitting cracks are observed at the edges of the rolling track and on the slower moving surface. The conclusion that, where rolling is accompanied by sliding or even local slip, pitting is more likely to affect the slower moving surface now seems to be fairly well established. As Mr. Milne observed, the cycle of stress experienced by the slower moving surface is one of tension followed by compression, which is consistent with the theory of crack propagation by trapped lubricant proposed by Way[8].

The paper by Dr. Crook suggested that another significant mechanism might be involved. Experiments on rolling mild steel disks under loads sufficiently large to exaggerate the amount of plastic flow were described[9]. He showed that two disks rolling under a purely normal contact force produce plastic shearing of a relatively undeformed surface layer, forward, in the direction of rolling, relative to the main body of the disk. The effect is independent of the presence of a lubricant. Running the disks at different speeds introduces frictional tractions at the contact surfaces, acting in the direction of rolling on the slower surface and opposed to it on the faster one. The effect of these tractions, as might be expected, is to accentuate the plastic flow of the slower surface and restrict or reverse that of the upper surface depending upon the coefficient of friction. In any event, it appears that the slower moving surface

experiences much larger plastic deformations than the faster one, which under lighter loads and with less ductile materials would be likely to lead to a shorter fatigue life.

The papers on rolling contact made it clear that stresses and distortions in rolling contact are likely to differ from those in a stationary contact under the same forces. Dr. Johnson explained this difference in terms of the different stress history of a surface element in the two cases. If either slip or plastic flow takes place, a difference in sequence of loading leads to a difference in the overall stress pattern. In particular, it was shown that slip at the contact surface begins at the trailing edge of the contact area and not at the leading edge. A method of approach to the theoretical problems of rolling contact was suggested in which the process is viewed as one of 'steady-flow' in the manner of hydrodynamics. This involves using the Eulerian co-ordinate system[10] in which the contact region appears as a stationary pattern of elastic distortion through which the material of both surfaces flows at a steady rate.

Taken as a whole, the symposium gave a valuable co-ordinated view of the present state of research into contact problems in Britain. K. L. JOHNSON

PAPERS PRESENTED AT THE SYMPOSIUM

Andrews, H. I., "Contact Stresses on Railways and Wheel and Rail Problems".

Ollerton, E., "Contact Stresses between Toroids under Radial and Tangential Loads".

Tabor, D., "Effect of Tangential Stresses on Plastically Loaded Contacts".

Storey, C., "Point Contact Effects—the Relevance of Hertz's Theory".

Gough, V. E., "Tyre to Ground Contact Stresses".

Milne, A. A., and Nicholson, A. M., "Pitting Failure—Some Studies in the Modified Four-ball Machine".

Crook, A. W., "Some Experiments upon Sub-surface Deformation in a Disk Machine".

Johnson, K. L., "The Rolling Contact of Elastic Solids viewed as a Steady-flow Process".

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THE METROPOLITAN-VICKERS IRRADIATION LABORATORY

THE opening on May 29 of the new Irradiation Laboratory at the Metropolitan-Vickers Barton works was performed by Mr. H. West, director of electrical engineering in the Company. In a short address he reminded his audience that the scientific and engineering contributions made by Metropolitan-Vickers to the development of high-vacuum equipment and particle accelerators have been prominent in keeping Britain to the forefront in this field. An inspection of the new laboratory certainly gave strong support to his claim.

The principal item of equipment in the laboratory is the 4-MeV. linear accelerator, which produces the beam of irradiating electrons. There is nothing fundamentally new about this unit; it has been adapted from the accelerator developed by the Company for its 4-MeV. X-ray machines which are already installed in several hospitals in Britain. The electrons, bunched together into small clusters and travelling in a hollow 'corrugated' wave-guide, are accelerated by a radio-frequency field which is produced by the propagation of radio-frequency power of short wave-length (usually 10 cm.) along the wave-guide. The design of the wave-guide is such that the velocity of propagation of the radio-frequency field matches that of the accelerating electrons, so maintaining the phase relationship between field and beam and ensuring the continuous acceleration of the electrons along the whole length of the wave-guide. A radio-frequency feedback system is used to increase the energy of the beam, which is released in pulses of 2 μsec. duration at a rate of between 50 and 500 pulses per sec. The power of the beam is of the order of 500 watts, corresponding to a mean beam current of 125 μamp. At the output end of the accelerator an alternating field fans out the electrons so that they scan an area of 12 in. × $\frac{3}{4}$ in. as they emerge from an aluminium foil window.

The construction of the laboratory itself leaves nothing to chance in the matter of safety. A system of interlocked doors ensures that access to the treatment room (surrounded by massive concrete walls with 4-in. steel plates at strategic locations) or to the accelerator room automatically renders the apparatus harmless. All the control equipment is centralized and is well clear of any radiation or high-voltage hazard. Articles to be irradiated may be mounted either on a variable-speed continuous conveyor belt or a specially designed work-table, both of which are operated by remote control.

The property which makes irradiation a useful process is the disruption which it causes, particularly in large molecules. When biological systems are irradiated, three types of change may occur. Slight irradiation will lead to no obvious damage to the organism, but through the agency of gene mutation may promote the evolution of new genetic types. This offers the interesting possibility that, by exposing quantities of seed to radiation, the probability of producing mutations and of occasionally finding some improved plant strain may be greatly increased. Greater doses of radiation may render sterile the irradiated organism. A suggested application of this property is the improvement of the storage properties of some vegetables, such as potatoes, by preventing them from sprouting.

However, the most fascinating possibilities seem to arise from the utilization of the lethal effects of very large doses of radiation as a bacteriocide. Foodstuffs which normally deteriorate through bacterial infection have their keeping properties much improved

by irradiation; unfortunately, the dosage required to exterminate the bacteria sometimes renders the food unpalatable, a difficulty which has still to be overcome. An even more attractive application is in the sterilization of certain types of pharmaceutical products; due to chemical instability or unfavourable physical properties, it may not be possible to use the usual high-temperature methods of sterilization, and irradiation may be used with a temperature rise of a few degrees only. In addition, the product may often be treated in its finally packaged state, ready for distribution.

The irradiation of polymeric substances frequently results in useful changes of their properties. These changes may be roughly classified into two types. In the first of these C—H bonds are ruptured to give a hydrogen atom and a free polymer radical. Two radicals combine to give a larger molecule, a process known as cross-linking, and a molecule of hydrogen is liberated. If the irradiation dosage is large, so many cross-linkages may be formed that the whole specimen becomes virtually a single huge molecule which is extremely inert chemically and insoluble in most solvents. The other type of change which may occur is known as degradation. The polymer is broken down into simpler hydrocarbons, some of which are gaseous and held in the substance under high pressure. Subsequent heating of the polymer softens it and allows this gas to expand, thus producing a foamed material the low density and other characteristic properties of which have found useful applications.

The new laboratory has been set up by Metropolitan-Vickers to provide an irradiation service for other industrial firms and organizations. In doing so the Company has demonstrated a degree of initiative which one hopes will be matched by its potential customers. It is pleasant to witness an industrial enterprise which is not content merely to keep abreast of current scientific advance but which also itself makes a noteworthy contribution to scientific progress.

THE PROGRESS OF WORLD HEALTH

ON April 7 the World Health Organization marked its tenth anniversary by sponsoring the celebration, on that date, of a World Health Day in London. As its director-general, Dr. M. G. Candau, said, there have been, during the past ten years, great scientific advances—new drugs, new vaccines, new and better insecticides, more effective methods of fighting or preventing disease. Governments have learnt to take responsibility for the health of their peoples and to provide not only hospitals and health institutions, but also better food and better care for mothers and the young; and eighty-eight countries are now members of the World Health Organization.

How much has been achieved was outlined by Dr. H. van Zile Hyde, chief of the United States Division of International Health. Infectious disease has handicapped man throughout his history. History has, in fact, often been changed by diseases such as typhus, influenza, plague and malaria. But in limited areas of the world in which it has been possible to apply the knowledge acquired by medical science, the epidemics of the past—cholera, smallpox, plague and yellow fever—are no longer feared. Malaria, prevalent in regions in which three-fourths of mankind live, has been conquered to such an extent that whereas, in 1948, 300 million people had malaria each year and 3 million died of it, these figures have to-day been cut by 30 per cent. This disease is still one of the most formidable menaces, but its eradication, already achieved in certain areas, is now possible almost everywhere in the world. It is likely that it will, in a few years, be controlled in the United States, and no new infections with it are expected in the U.S.S.R. after 1960. In the eastern Mediterranean, a traditional reservoir of the disease, great progress in its control has been made. The most serious problem is presented by Africa south of the Sahara, but here also much has been achieved.

The list of other scourges controlled is long and encouraging. Respiratory diseases, such as pneumonia, the common cold and influenza, still flourish; but whooping cough, though it still resists, is in retreat. The international spread of epidemic diseases, formerly controlled by quarantine regulations which imposed great hardships and delays in travel and commerce, is now reduced, in spite of increased possibilities of spread of these diseases by the aeroplane, to the relatively easy conditions of the International Sanitary Regulations designed by the World Health Organization and adopted in 1951.

Many diseases formerly feared, such as cholera, typhus, smallpox, yellow fever, tuberculosis, and those menaces of childhood, scarlet fever, measles and diphtheria, are now virtually under control and, if they occur and are properly handled, they rarely kill. The decline of mortality is, in fact, one of the most significant features of the health record of the world, but it creates new problems that are serious. More elderly people must be fed and housed and given work; the diseases of later life, such as cancer, diabetes and heart disease, are commoner. The stress of modern life is also taking its toll, and great quantities of drugs are manufactured to counter this stress. Whereas infectious and parasitic diseases have been reduced by half, accidents, especially among the young, are leading causes of death. For the very young, on the other hand, and for the mothers who bear them, there is much greater chance of health and happy life.

Thus people born nowadays may expect, apart from accidents, a safer, longer and happier life than earlier generations could. They owe this, of course, primarily to the work of men and women of all nations who have provided the knowledge on which this remarkable progress has been based, and also to the work of the World Health Organization and kindred organizations which have integrated and correlated the work done by individuals and teams in various parts of the world. A major problem of the future would seem to be the diseases of later life, such as cancer, diabetes and arteriosclerosis. If so much has been done in a decade, there is every hope that these diseases also will soon be added to the list of scourges that man has overcome.

G. Lapage

EAST AFRICAN VIRUS RESEARCH INSTITUTE

THE annual report* of the East African Virus Research Institute, Entebbe, for 1956–57, which includes a list of papers published during the year and a list of scientific and technical staff as at June 30, 1957, records that the mechanism of transmission and maintenance in Nature of the arthropod-borne viruses continue to be the main interest of the Institute. A systematic programme was commenced to identify the viruses concerned in the causation of fever in man in Uganda. Rabies were recorded in the Entebbe area for the first time and the Institute was largely responsible for identifying the agent. Studies on *Arvicanthis abyssinicus*, a common rodent in Uganda, indicated that it may be important as a host in maintaining Rift Valley fever virus in Nature. Two strains of Zika virus were isolated from *Aedes africanus* mosquitoes collected in forest near Entebbe.

Much attention continued to be given to yellow fever. Some modifications were made in yellow fever neutralization test methods. A more detailed analysis of the sera collected in Northern Rhodesia in 1950–52 indicates that in the four districts mainly involved both sexes are exposed to infection, but rates are generally higher in males than in females; in males infection-rates generally increase with age. In several tribes or localities this is true of females only up to about twenty-four years of age. Twenty-five monkey sera from Tanganyika were all non-immune, but five immune individuals were found among thirteen Brazza's monkeys (*Cercopithecus neglectus*), and laboratory studies indicated that this monkey was likely to be an efficient host for yellow fever virus in Nature. No antibody could be detected in the study of the hæmagglutination inhibition antibody reaction of a bush-baby (*Galago crassicaudatus*) on infection with yellow fever virus.

In the entomological field most attention has been devoted to mosquitoes, especially *Aedes* (*Stegomyia*) spp. The intermittent trap for sampling insects attracted to live bait continued to give encouraging results. Studies are reported of the oviposition cycle in *Aedes aegypti*, *A. africanus* and *Taeniorhynchus fuscopennatus* and of the hormonal mechanisms involved in the reproductive cycle of mosquitoes. Extensive studies of *Aedes aegypti* both in Entebbe and on the Kenya coast, to determine whether the population of this species is made up of 'races' differing biologically, indicate that man is an important host both in Uganda and on the Kenya coast. The hosts of some other mosquitoes have been determined: *A. simpsoni* feeds mainly on man; *Taeniorhynchus fuscopennatus* feeds mainly on mammals and the other *Taeniorhynchus* spp. attack mainly birds.

* East Africa High Commission. East African Virus Research Institute Report, July 1956–June 1957. Pp. iv+61. (Nairobi: Government Printer, 1957.) Sh. 5.

ARIZONA METEORITE CRATER

DURING the summer of 1956 the Smithsonian Astrophysical Observatory sent an expedition to investigate the distribution of pieces of meteoritic material that are scattered through the mantle of soil surrounding the Arizona Meteorite Crater, the object being to determine more accurately the mass of the meteorite that made the crater and also the direction of its flight. J. S. Rinehart has now published the results of this survey (*Smithsonian Contributions to Astrophysics*, 2, No. 7: "Distribution of Meteoritic Debris about the Arizona Meteorite Crater". Pp. ii+145–160. Washington, D.C.: Government Printing Office, 1958. 20 cents). Niniger had previously worked on the same subject and had published his results in 1956 with his method for extracting the meteoritic material from the soil surrounding the crater, but Rinehart's method was different. He developed a special magnetic separator consisting basically of a vibrating hopper and a slanted trough down which the soil moves under the combined action of gravity and vibration. Above the trough were suspended three strong 'Alnico' magnets to which the magnetic material flies up and adheres as the soil moves downwards. Many precautions were necessary to secure reliable results and these are described very fully.

Estimates of the total mass of finely divided meteoritic material around the crater suggested that this is about 12,000 tons, but this figure is subject to some uncertainty. It is believed that about one-fourth of this mass may be terrestrial oxygen that combined with the meteoric iron after its encounter with the Earth. In addition, there does not appear to be any way for ascertaining accurately the amount of contaminating material present. After taking into consideration a number of uncertain factors, it is believed that the computed mass of 12,000 tons may have to be reduced by about 10–20 per cent.

It is suggested that the meteorite approached the Earth from a south-westerly direction, and after the collision threw forward large quantities of meteoritic material to the position where it now rests. As no piece more massive than 2,000 lb. has ever been found, while thousands of pieces weighing a few ounces or less have been recovered, it is believed that the meteorite was shattered into fragments when it struck the Earth, melting and evaporation accompanying this disintegration. The results so far provide no indication as to whether a large mass of meteoritic material lies buried in the crater. If we accept the low estimates of 10,000–15,000 tons for the mass needed to form the crater, then no large mass could remain in the crater. If, on the other hand, the estimates of Öpik and of Rostoker are nearer the true value, then the amount of meteoritic debris so far recovered is insignificant, and a large mass may be buried underneath. Dr. F. L. Whipple, in a personal communication to the author, expresses the view that a most reasonable mass is that given recently by Hill and Gilvarry, namely, between 80,000 and 400,000 tons.

MEANING OF DENSITY-DEPENDENCE AND RELATED TERMS IN POPULATION DYNAMICS

ONE of the most familiar concepts of population dynamics is the idea of the regulation of abundance by density-dependent factors, which operate more severely at high density than at low density, per individual of a population. But there has been some variation in the meaning and scope of 'density-dependent' and related terms as used by different authors, and in recent years this tendency has increased. This has led to some confusion, and poses the question how the application of these terms can be stabilized. Varley[1-3] has argued that the meaning and scope of such a term should be determined strictly according to its author's definition, and that on this basis insect parasites, predators and disease organisms should be excluded from the density-dependent category. Discussion of this matter with Prof. Varley has not altered my opinion that it is too late to attempt to make a change so contrary to the intentions of the originator of this term, and to subsequent common usage, but has led to various improvements in the present article.

In order to deal with a number of points which are closely inter-related, it is proposed: (1) to look back to the origins of the terms concerned, then (2) to give a brief account, similar in some respects to that given by Varley[3], of the variations in the use of these terms by various authors, and of a number of synonyms, and finally (3) to discuss various proposals for clarifying the position.

(1) Howard and Fiske[4], discussing the natural control of insects with special reference to defoliating caterpillars, wrote that for natural control, or balance, to exist "it is necessary that among the factors which work together in restricting the multiplication of the species there shall be at least one, if not more, which is what is here termed facultative . . ., and which, by exerting a restraining influence which is relatively more effective when other conditions favour undue increase, serves to prevent it". The chief of such facultative factors was stated to be parasitism, "which in the majority of instances, though not in all, is truly 'facultative'".

They considered disease as a type of facultative factor which, in their experience, became effective chiefly at a very high level of abundance, and starvation as operating only at the extreme limit. Generally, insects would be controlled at a low level of density "only through parasites and predators, the numerical increase of which is directly affected by the numerical increase of the insect upon which they prey".

Secondly: "A very large proportion of the controlling agencies, such as the destruction wrought by storm, low or high temperature, or other climatic conditions, is to be classed as catastrophic, since they are wholly independent in their activities upon whether the insect which incidentally suffers is rare or abundant. . . . The average percentage of destruction remains the same. . . ."

Thirdly: "Destruction through certain other agencies, notably by birds and other predators, works in a radically different manner . . . it may be considered that they average to destroy a certain gross number of individuals each year, and . . . this destruction . . . would most probably represent a heavier percentage when that insect was scarce than when it was common. In other words, they work in a manner which is the opposite of 'facultative' as here understood."

In short, Howard and Fiske recognized three types of factors: (*a*) 'catastrophic'; (*b*) 'facultative' and a third type which was later called (*c*) 'inverse'[5]. Later, Thompson[6] divided controlling factors into two classes. One, which he named 'general', was the same as Howard and Fiske's catastrophic type. The other comprised "those *individualized* factors whose destructive capacity depends in some way on the numerical value of the host population"; this definition takes in two of Howard and Fiske's categories, the facultative and the inverse factors; it is clear from this paper and from Thompson's later writings[7] that he means chiefly parasites, but he considers that, because of their limited reproductive capacities, they generally act as inverse factors.

It was H. S. Smith[8] who introduced the new terms 'density-independent' and 'density-dependent' for Howard and Fiske's catastrophic and facultative categories. He made the mistake of identifying the facultative or density-dependent class with Thompson's individualized category; but his designation, "destroying a percentage which increased when the numbers of the host increased", shows that he did not mean to include inverse factors; indeed, he followed Howard and Fiske in recognizing them as a distinct third category, again citing "many insectivorous birds and mammals" as examples. His examples of density-independent agents included climatic factors, 'intrinsic' mortality, and malnutrition due to unsuitable food. Examples of density-dependent factors were, primarily, entomophagous insects, then certain infectious and contagious diseases, quantity of food and competition for nesting sites or protective niches; the last-mentioned process, it was suggested, was a medium through which climatic factors could have a density-dependent action.

Thus Smith and Howard and Fiske agreed in designating facultative or density-dependent factors as those having a greater proportionate influence at high than at low population density, and also in regarding insect parasites, or entomophagous insects (Smith), certain pathogens, and food shortage as examples; Smith added intra-specific competition, and hence (in his view) certain climatic factors. Varley[1-3] has insisted that the definition and the examples are at variance, inasmuch as theoretically constructed parasite-host oscillations show a relationship which, owing to the delayed response of parasite numbers to changes in host numbers, is alternately density-dependent and inverse. It may be added that interactions broadly similar to the theoretical ones have been demonstrated in laboratory experiments and in a fragmentary form in certain field populations, though not in others. Nevertheless, the great majority of writers on the subject have accepted Smith's ideas and terms, presented as they were

without formal definition, and have been content to use them in a not too precise way; in particular, most writers have accepted all those insect parasites and predators exerting a regulating influence upon a population as density-dependent factors; whether or not their response to host density might be so delayed as to prevent any consistent and straightforward density-dependence has been little considered.

(2) There have, however, been a number of variations in the application of Smith's terms, and various new terms have been used by authors wishing to avoid confusion. The term 'density-independent' has suffered relatively little misuse. But in his text-book, Odum[9] refers to a type of inverse factor as density-independent, and uses a new term, 'density-proportional', for one type of density-independent factor.

With respect to the term 'density-dependent', a major source of confusion is that some authors have taken it to include inverse factors, which Smith specifically excluded. Allee[10] and Allee *et al.*[11] did this, and then separated 'direct density-dependent' from 'inverse density-dependent' factors. Haldane[12] did likewise, but called these two subdivisions 'negative' and 'positive density-dependent'. Thompson[7] writes that Smith proposed the new term 'density-dependent' for Thompson's individualized category. This, as already noted, was an error on the part of Smith[8]; for, like Howard and Fiske[4], he explicitly separated the inverse type of factor into a separate category.

Milne[13] makes a distinction between 'perfectly' and 'imperfectly' density-dependent factors: "Perfection here means an *exact* linear (or curvilinear) relationship between increasing action of the factor and increasing density of the species". The only perfectly density-dependent factor is said to be competition between members of the population. I do not believe that factors perfectly dependent on density exist except at a high level of abstraction. In Nature, the actions of all factors are presumably variable and inexact.

Varley[1,2], in separating parasites, predators and pathogens from the density-dependent category, called them 'delayed density dependent' factors. Lack[14] has treated this new category as a subdivision of the density-dependent class.

Some synonyms of density-dependent are 'facultative'[4], 'controlling'[15], 'concurrent'[5] and 'density-governing'[16].

'Inverse' factors of various types have been called 'density-disturbing'[16], 'inverse density-dependent'[10,11], and 'positive density-dependent'[12]. Odum[9] refers to one sort of inverse action as an inverse type of density-dependence, and to another sort as density-independent. The terms positive or inverse density-dependent, as we have seen, extend the density-dependent category beyond the limits laid down by its originator.

There is, of course, an important characteristic held in common by density-dependent and inverse factors: the action of both is related to population density, though in opposite senses. Terms (other than density-dependent) which have been used for including both these types of factors together are 'individualized'[6], 'density-related'[5] and 'reactive'[16].

(3) Turning now to the question how to standardize the use of the term density-dependent and reduce the confusion which has beset it in the past, there are three main possibilities:

(*a*) The first is to follow the course advocated by Varley[2,3], and place a strict interpretation on the explanations (scarcely formal definitions) given by Howard and Fiske[4] and by Smith[8]. What the result of this would be depends upon whether or not many insect parasites and predators do in fact maintain an oscillatory relationship, of the type seen in mathematical theories, with the populations of their hosts or prey. If Varley's[3] expectations are correct, parasites and predators would generally be excluded from the density-dependent category of which Smith took them to be the prime exemplars. Besides running counter to the intentions of the originator of the term, this would give density-dependence a far narrower meaning than it has been given throughout the extensive literature in which it has been used over the past two decades. (The only exceptions to this, so far as I am aware, are papers by Varley[1-3].) I believe such a restriction of the scope of this familiar term would be unlikely to find general acceptance, and that after such a long period it would cause a great deal of further confusion if it were adopted.

(*b*) The second possibility is to follow the example of Allee[10], Allee *et al.*[11], and Thompson[7], and take the density-dependent category to include, not only all the types of factors attributed to it by Smith, but also the inverse factors, which he excluded. In support of this course, it may be said that it has been fairly widely favoured, and that it interprets density-dependent in the literal sense of "acting in a way which is dependent on density". But I doubt whether it accords with a majority viewpoint, and am opposed to it because it gives the term density-dependent a quite different scope from that laid down by its originator.

(*c*) The third possibility is to follow the intentions of Smith as closely as possible, by including, along with intraspecific competition and other straightforward density-dependent factors, those parasites, predators and pathogens which respond to changes in host population density in such a way as tends to limit these changes (even if the response is delayed as in the theoretical parasite/host oscillations), and by excluding only those factors the action of which wholly or predominantly maintains an inverse relationship with density, and those which are independent of density. Many writers have explicitly or implicitly adopted a similar interpretation. I suggest that, in so far as the term 'density-dependent' continues in use, this is the way in which it should properly be applied.

Whichever course is followed, one major difficulty is inescapable for the present: there are very few ecological situations which are well enough known for particular biological factors to be placed with confidence in any one of Smith's three categories. Still less can we say in general what proportion of insect parasites and predators act as density-dependent, or inverse, or density-independent factors.

The writer on this subject may often prefer to avoid using the term 'density-dependent'. One alternative is to use Nicholson's term 'density-governing'. Nicholson[16] writes that "its meaning is precisely that of 'density-dependent factor' according to definition (Smith, 1935)", and, like Smith, he puts inverse factors in a separate category (density-disturbing). A possible objection to the term 'density-governing' is the implication that all density-dependent factors have a governing influence upon density, which seems unlikely.

As a means of avoiding the various difficulties associated with the use of 'density-dependent', and at the same time recognizing the special features of the factors Varley[1] called 'delayed density dependent', the following classification may be useful. It sets

out some types of relation which the unfavourable action of factors upon a population may bear to the density of that population, the action being measured as an effect upon mortality, the reproductive rate, or the net rate of increase or decrease, and expressed in proportionate terms such as percentage.

(1) 'Directly density-related' : showing a positive correlation between adverse action and density.

(2) 'Inversely density-related' (or 'inverse') : showing a negative correlation between adverse action and density.

(3) 'Alternately density-related' (or 'alternating') : where a lagging response to changes in density leads to a regular succession of directly and inversely related phases.

This last category is distinguished from the density-independent (or non-reactive[16]) relationship, where the correlation between action and density would generally vary (in successive short runs of observations) in an irregular manner between positive, zero and negative, with a long-run correlation not differing significantly from zero.

A single factor might fall in different categories in different circumstances, or at different levels of abundance or (as pointed out to me by Dr. R. F. Morris, of Canada) within a single generation as compared with a series of generations.

Upon such questions as what sort of ecological causes may lie behind the correlations observed, which factors may be found to fall in which category under various conditions, and what may be their function in natural control, this classification is deliberately left non-committal.

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Mr. Solomon directs attention to a serious state of affairs which is making the study of population dynamics unnecessarily confusing. While agreeing with his analysis of the past use and misuse of the terms, I think that the reasons for the confusion require closer study, and I also disagree with his recommendations. This disagreement involves the principles on which scientific terminology should be based, and it would be interesting to have the views of workers in other fields of science, where there are comparable difficulties.

Here the issue in question concerns the way in which animal populations are stabilized, and there are at least two quite different models which may be used for explaining such stability, and mortality relationships appropriate to each require different terms if confusion is to be avoided. The first and simplest is that of Verhulst, Pearl and others which considers one species only, and assumes that its relative rate of increase is reduced by rising population density. There is a single population density at which the rate of increase is zero. Whether the population density is initially above or below this it will rapidly approach this equilibrium position. In my opinion a mortality factor which stabilizes a population in this way fits best with Smith's term 'density-dependent'.

The second model is more complex and concerns the interaction between two species, predator and prey, or parasite and host. It has been studied mathematically by Lotka, Volterra and in a special form by Nicholson and Bailey. On this model populations show oscillations, and mortality in the prey or host species does not show a simple relationship to its own population density. Actually, the maximum mortality lags a quarter of a cycle behind the population density. Hence my term 'delayed density-dependent factor' (Varley, 1947). Similarly, the maximum rate of increase of the predator or parasite is a quarter of a cycle after its own population minimum, so that the effect is delayed, being density-dependent for two quarters of the cycle, and inverse for the other two.

From the beginning there has been confusion between these two models. Howard and Fiske's explanation (*l.c.*, p. 107) of their term facultative has been quoted in part by Solomon, but the phrase "when other conditions favour undue increase" is vague ; they also say (p. 108) that facultative agencies "effect the destruction of a greater proportionate number of individuals as the insect in question increases in abundance", which is consistent with model one. They did not seem to appreciate that model two was basically different. They realized that parasites and predators had a regulatory influence on populations, and cited them as examples to which their term applied. There is, however, no evidence from studies of parasite behaviour to warrant this citation.

Nicholson (1933) likewise seems to confuse the models. Having given examples of balance of populations of *Tribolium*, etc., *in vitro*, he says (*l.c.*, p. 135) that "for the production of population balance, it is essential that the controlling factor should act more severely against an average individual when the population density is high, and less severely when the population is low". Such a controlling factor clearly agrees only with model one, and the examples he had just considered have often been fitted by the Verhulst–Pearl equation. Nicholson then proceeds to elaborate his theory of population balance by parasites, which is a form of model two. He does not point out that according to his theory the host's mortality due to parasitism reaches its maximum not when host density is maximal, but when it is half-way down to its minimum again. Hence parasites, according to his theory, do not fit his definition of controlling factors which I have quoted. Nor does Nicholson seem to recognize the distinctive nature of model two even in his 1954 paper.

A second cause of confusion, as rightly pointed out by Mr. Solomon, is that certain workers have interpreted the term 'density-dependent' literally, and divorced it from its original restricted definition. This I consider to be deplorable, and contrary to

general scientific practice. Thus biologists do not apply the term 'chromosome' to any coloured body.

Thirdly, as seen from Solomon's review, various workers have re-defined and used the term 'density-dependent' in different or even in opposite senses from that originally defined. This raises the question whether scientists should adopt rules for the purpose of conserving the meaning of terms.

Mr. Solomon considers three ways of treating Smith's term 'density-dependent', and favours the last, (*c*), which is to sanction the application of the term to parasites and predators. This puts more weight on Smith's examples than on the definition or explanation of Howard and Fiske to which Smith referred. Further, this course probably involves the rejection of the original definition of the term, and therefore the provision of a new definition. Since Thompson and Nicholson have entirely different ideas about the ways in which parasites react to host population changes, and observations are as yet inadequate to give a clear decision[1], an agreed definition cannot be given at the present time if parasites are to be an example of the term's correct application. Is it not wiser for the present to refer to these animals simply as parasites or predators, and avoid being committed to any particular hypothesis concerning their influence on populations ?

The second solution (*b*) which Solomon rejects would also require a formal change in the definition of the term 'density-dependent'. Although various authors have used the term in senses different from that originally defined, I agree with Solomon that there seems to be no valid reason for following any of them. The consequences of permitting scientific terms to be altered in such a way are serious.

I am convinced that the best course, though Solomon rejects it, is to accept a precise definition of 'density-dependent' in accordance with model one, which I believe to be what the original authors had in mind, and it is in this sense that I have interpreted the term in the papers cited. This, it is true, means that parasites and predators are excluded as examples, but as already stressed, their action probably conforms more to model two. While Solomon claims that to narrow the scope of the term in this way is confusing, I think that distinctive terms are required for mortality relationships in the two models, and that this will help to clarify the issues involved.

Possibly there is a case for rejecting all these old terms simply on the grounds that they have been perverted and inverted by various authors ; but on balance I prefer to use them and to retain their original definitions. I can see little advantage in adopting Solomon's three new terms, although they provide a good logical system, since they are synonyms of terms already in use. If these new terms come to be misused in the future, must they be cast aside in turn ?

I am grateful to Dr. D. Lack for discussing a draft of this reply, and helping to remove some ambiguities.

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BITING BEHAVIOUR OF MATED AND UNMATED FEMALES OF AN AFRICAN STRAIN OF *AEDES AEGYPTI*

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IN the course of extensive studies on the biting behaviour of an African strain of *Aedes aegypti*, which has been maintained in the Liverpool School of Tropical Medicine since 1938, it was observed that the mated and unmated females behaved differently. Gillett[1-3] has studied the development of the oocytes and the oviposition habits of several African strains of the same species of mosquito and has provided evidence for the presence of an ovarian development hormone and suggested the existence of an ovulation hormone, the production of which appears to be usually dependent on previous mating. While the investigations being undertaken in Liverpool are not directly concerned with a study of these hormones, the experiments described in this preliminary communication may throw some further light on the hormonal control of gonadotrophic activity in the mosquito.

In each of the experiments in which the biting behaviour of fertilized and unfertilized mosquitoes was compared, the adult insects were obtained from the same 'crop' of pupæ so that both populations were exactly comparable. The mosquitoes were kept in organdy cages in an insectary, the temperature of which varied between 75° and 85° F. and the relative humidity between 70 and 82 per cent ; illumination was provided only during the day, by means of neon lamps. Feeding on a sensitized human volunteer was begun on the second day after emergence when a high proportion of the mosquitoes were likely to feed[4], and the flies were afterwards offered a meal on the same volunteer for exactly 5 min. daily.

The results of the experiments, which were carried out in the summer of 1957, showed that the numbers of fertilized mosquitoes which fed decreased markedly in the first few days, the lowest level of feeding corresponding with the onset of the oviposition-cycle. Feeding in the fertilized mosquitoes then showed a cyclical pattern with the intervals corresponding to those of the oviposition-cycle. On the other hand, in the case of the unfertilized mosquitoes, biting was maintained at a high level from the onset of feeding, while the egg output was very low ; in its oviposition habits the Liverpool strain of *A. aegypti* appears to behave similarly to the Newala strain described by Gillett[1]. There was a slight variation in the various experiments carried out, but the basic pattern as illustrated in Fig. 1 was repeated, particularly in the

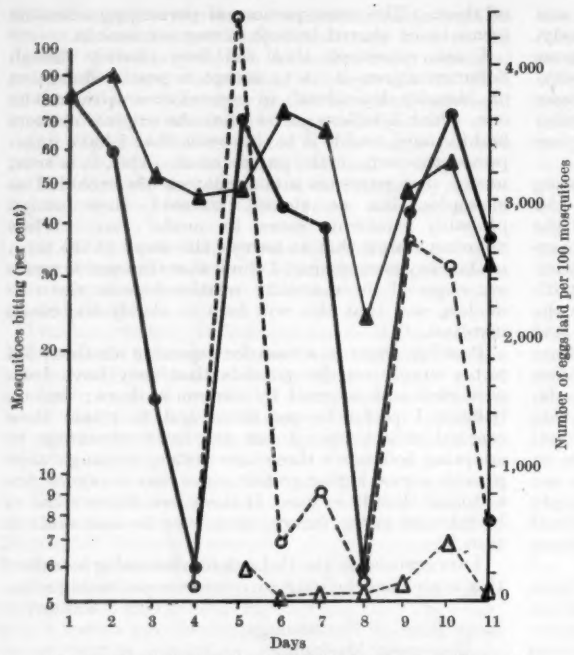

Fig. 1. Graph showing the relationship between the biting and oviposition curves of a group of 52 fertilized *Aedes aegypti* and the relationship between the biting and oviposition curves of a comparable group of 52 unfertilized *A. aegypti*. The biting curves are plotted on semi-logarithmic co-ordinates and the oviposition curves are plotted on arithmetical co-ordinates. The experiments were started on July 2
●, Fertilized biting curve; ▲, unfertilized biting curve; ○, fertilized oviposition curve; △, unfertilized oviposition curve

first few weeks of each experiment. As the populations aged the picture was not quite so clear cut, due to a number of complicating factors, the nature of which will be discussed when a full account of these results is published.

Dissections of a control group of fertilized mosquitoes belonging to the experiment illustrated in Fig. 1 showed that biting fell off sharply after the oocytes had reached the third stage, and that mosquitoes which fed at the late third or fourth stage of oocyte development generally took smaller meals than mosquitoes with oocytes of an earlier age. In a group of 55 fertilized mosquitoes, only 2 out of 23 flies which had fifth-stage oocytes had taken a blood meal and both presented abnormal features; in one individual only the right ovary contained fifth-stage oocytes, while in the other mosquito each ovary contained only a few fifth-stage oocytes. On the other hand, dissections of a comparable control group of unfertilized mosquitoes, carried out on the fifth day, revealed that all the mosquitoes possessed oocytes at the fifth stage of development although biting was proceeding at a high level. These results are of great interest when compared with those of field workers such as Teesdale[5] and Macdonald[6].

The explanation of the sharp reduction in the biting activity of the fertilized females, as the oocytes developed, is not clear. It is certainly not due to a pressure effect, since unfertilized females with retained and pigmented eggs, and with an extensive fat body, readily took up blood. It therefore appears probable that avidity for blood is under hormonal control and closely associated with events in the gonadotrophic cycle of the ovipositing mosquito. While it is manifestly dangerous at the present stage of our knowledge to speculate too freely about the mechanisms controlling cyclical feeding, it is tempting to suggest that the production of increasing amounts of ovulation hormone in the gravid fertilized mosquito inhibits the mechanisms by which the mosquito is induced to feed and that this inhibitory effect is very rapidly removed following oviposition. Whatever the final answer to the problem, it probably will not prove to have a simple solution.

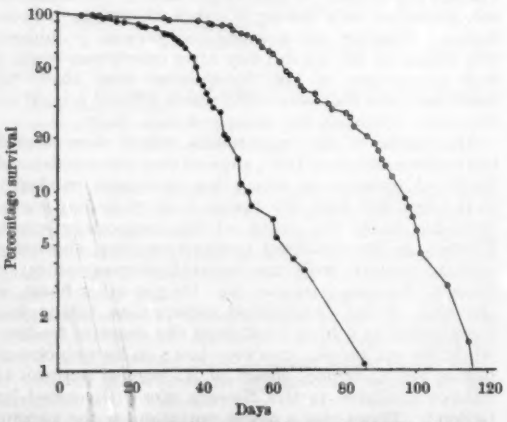

Fig. 2. Survival curves for comparable groups of fertilized ○ and unfertilized ● *Aedes aegypti* which had been offered a blood meal daily, plotted on semi-logarithmic co-ordinates

Studies on the survival of fertilized and unfertilized populations of *Aedes aegypti* which were offered a blood meal daily showed that the rate of death of unfertilized females was greatly increased when compared to that of fertilized females (Fig. 2). That the increased rate of death of the unfertilized females was not due directly to the effect of feeding but to some factor or factors associated with the retention of the ova was shown by the fact that two curves plotted for unfertilized populations, one of which was offered a blood meal daily and the other every 10 days, coincided almost exactly.

Finally, it should be noted that the term 'biting cycle' is used in this context to describe the type of cyclical biting activity shown in Fig. 1 in accordance with Kleitman's[7] nomenclature. This is not to be confused with the nycthemeral biting curve which is usually referred to as the 'biting cycle' and which appears to be controlled by factors other than those discussed in this paper. While it may be necessary in the future to reconsider carefully the nomenclature of cyclic, rhythmic and periodic phenomena in mosquito biology, it is my feeling that this can only be done profitably when more is known about the mechanisms which control the vital activities of the insect.

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DEVELOPMENT OF LYSOZYME-RESISTANCE IN *MICROCOCCUS LYSODIEKTICUS* AND ITS ASSOCIATION WITH AN INCREASED O-ACETYL CONTENT OF THE CELL WALL

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FROM a typical lysozyme-sensitive strain of *Micrococcus lysodiekticus*, resistant variants have been obtained by serial subculture on nutrient agar containing increasing amounts of lysozyme[1]. The most resistant of these variants, strain 250, grows on nutrient agar containing 4,000 μgm./ml. lysozyme, whereas the parent strain *L2* (N.C.T.C. 2665) fails to grow on nutrient agar containing 0·1 μgm./ml. of the enzyme. Cell walls prepared from the two strains show marked differences in their sensitivity to lysozyme action as measured either turbidimetrically or by release of N-acetyl hexosamine[2] as shown in Table 1. In this experiment the cells of strain 250 from which the walls were obtained were grown on nutrient agar containing 1 μgm./ml. lysozyme to inhibit the growth of sensitive variants.

Various explanations for the lysozyme-resistance of strain 250 have been sought[1], but particular attention has been given to the possibility of a chemical alteration in the cell wall, since this structure contains the substrate of lysozyme[3]. Analysis of the cell walls of strains *L2* and 250 revealed no major differences in their sugar or amino-acid composition[1]. However, when O-acyl estimations were made by the method of Hestrin[4], a marked difference between the two strains was revealed. The results in Table 1 show that the cell walls of the resistant strain contained more than one-hundred-fold greater content of O-acyl groups than th cell walls of the sensitive strain. Similar differences were also observed with whole cells. Paper chromatography[5,6] has identified the acyl groups as being principally acetyl.

These observations suggested that the lysozyme-resistance of strain 250 might be due to the ability of this organism to acetylate certain cell wall hydroxyl groups, associated with the lysozyme substrate, which in the sensitive strain are free. On the basis of this hypothesis, we have explored the possibility of using chemical procedures to alter artificially the lysozyme-sensitivity of *M. lysodiekticus* cell walls by changing their O-acyl content. Thus we have tried to make the resistant cell walls sensitive again by removing the O-acetyl groups with sodium hydroxide and, conversely, to render the cell walls of the sensitive strain resistant by acetylation with acetic anhydride and pyridine. That these experiments were successful is shown in Table 1.

By milder treatment it was possible to make the intact cells of strain 250 sensitive to lysozyme, but without the loss of viability that accompanied treatment with 0·01 *N* sodium hydroxide. For this purpose the cells were incubated 1 hr. at 37° in 0·1 *M* Sørensen phosphate or glycine buffers over the range

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Table 1. Comparison of O-Acyl Content and Lysozyme-Sensitivity of the Cell Walls of Sensitive (*L2*) and Resistant (250) Strains of *M. lysodiekticus*, and the Effect of Previous Treatment of Cell Walls with (*a*) Sodium Hydroxide, (*b*) Acetic Anhydride and Pyridine

Strain	Treatment	O-Acyl content of cell wall (μ*M*/gm.)	Lysozyme sensitivity*	
			Percentage reduction in O.D.	Glucosamine released (mgm. per cent cell wall)
			After 90 min. at 37°	
L2	None	3	68	3·1
250	None	433	15	0·4
250	NaOH	5	62	2·2
L2	Ac_2O/pyr.†	305	26	0·8

* In lysis tests the lysozyme concentration was 1 μgm./ml. while in estimations of glucosamine release 10 μgm./ml. was used. O.D. estimations were made on the Spekker, using grey filters.

† 80 mgm. cell walls + 20 ml. acetic anhydride + 1 ml. pyridine, 1 hr. at 37°, followed by washing at 0° in *p*H 7 phosphate buffer, first 0·2 *M* (twice), then 0·01 *M* (thrice).

Armour Laboratory crystalline egg-white lysozyme was used throughout this work.

*p*H 7·0–11·4, after which they were washed repeatedly in 0·01 *M* phosphate buffer *p*H 7·0 at 0°. It was found that although no significant loss of viability occurred up to *p*H 11·4, there was a progressive decrease in O-acetyl content and a corresponding increase in lysozyme sensitivity with increasing *p*H (Table 2). This increased sensitivity to lysis was associated with increased release of N-acetyl glucosamine, which is regarded as a reliable index of breakdown of lysozyme substrate[1]. Subculture of the cells rendered sensitive to lysozyme by treatment at *p*H 11·4 produced colonies the cells of which were once more lysozyme-resistant. It is therefore concluded that strain 250 differed genotypically from strain *L2* in its ability to acetylate cell wall hydroxyl groups. That at least some of these groups are located on the bacterial surface is suggested by the ease with which they can be removed without affecting cell viability. Thus in addition to natural selection, simple chemical treatment can be used to alter the susceptibility of *M. lysodiekticus* to lysozyme, except that the chemically induced changes are not transmitted.

Table 2. Exposure of a Lysozyme-Resistant Strain of *M. lysodiekticus* to Alkaline Buffers: Effect on Lysozyme-Sensitivity and O-Acyl Content of the Intact Cells

Treatment (*p*H)	Reduction in O-acyl content of cells (per cent)	Lysozyme sensitivity (per cent reduction in O.D.)*
7·0	0	30
8·4	8	37
9·2	11	48
10·3	31	53
11·4	39	75

* Concentration of lysozyme was 2 μgm./ml.

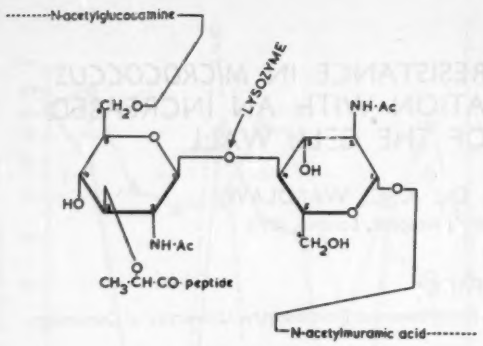

Fig. 1

These findings have led us to speculate on the possible locus of the O-acetyl groups in the cell wall and also on the nature of the bond split by lysozyme. Cell walls of Gram-positive bacteria have a remarkably similar chemical composition[7–9], being composed of three or four amino-acids and two amino-sugars: N-acetyl glucosamine and N-acetyl muramic acid. However, some of these bacteria are sensitive to lysozyme and others completely resistant. When lysozyme acts on susceptible cell walls only a few bonds in the substrate polymer are split, and large molecular weight fragments (10,000–15,000) with N-acetyl hexosamine end-groups are liberated[10]. Based on the results of a differential colour test, it appeared probable that these end-groups are all N-acetyl muramic acid[11] (although if N-acetyl glucosamine were still linked to the polymer through carbon 3, the same colour reaction would be given). The finding that only about 10 per cent of the total N-acetyl muramic acid in susceptible cell walls is made available by the action of lysozyme is in keeping with the size of molecular fragments released.

Disaccharides of N-acetyl muramic acid and N-acetyl glucosamine have been obtained following lysozyme action[10] and acid hydrolysis[12]. It is probable that this disaccharide forms the backbone of the polymer, although beyond this the structure of the mucopolysaccharide attacked by lysozyme is unknown. Assuming for the structure of the cell wall polymer repeating units of the two amino-sugars, let us now consider the possible linkages between them (Fig. 1). The colour yield of the split products in the Elson and Morgan test[13,14] following lysozyme action indicates that carbons 1 and 4 of N-acetyl muramic acid are free. Thus only carbon 6 is available for binding to the rest of the fragment, presumably to carbon 1 of N-acetyl glucosamine. On the other hand, the lysozyme-sensitive bond is probably from carbon 1 of N-acetyl muramic acid to carbons 3, 4 or 6 of N-acetyl glucosamine. It is very likely that lysozyme attacks only one of these bonds, and Berger and Weiser[15] have recently shown that chitin, which is a β 1–4 linked polymer of N-acetyl glucosamine, is slowly split by lysozyme. For this reason we propose the hypothesis that lysozyme splits a 1–4 link between N-acetyl muramic acid and N-acetyl glucosamine.

The effective inhibition of lysozyme by O-acetyl seems to require one acetyl per disaccharide unit. We have found an approximate 1 : 1 molar ratio of O-acetyl to N-acetyl muramic acid in the cell walls of our resistant strain 250. As mentioned earlier, lysozyme does not appear to split readily the bond between adjacent repeating units of the polymer, but acts preferentially on bonds about 10 units apart. From this one would predict that a fully resistant strain would become highly sensitive if only every tenth repeating unit were deacetylated, provided the deacetylated units were properly spaced. The results in Table 2 show that removal of only 40 per cent of the O-acetyl groups from the resistant organism was sufficient to confer high sensitivity to lysozyme. Abrams[16], who first observed the presence of O-acetyl in bacterial cell walls, concluded that these groups were not involved in lysozyme resistance because *Streptococcus faecalis* No. 9190, which contains O-acetyl, is sensitive to the enzyme. We would predict that this organism possesses less than one O-acetyl group per repeating unit and that resistant strains obtained by selection would possess a higher O-acetyl content.

This mechanism of resistance to lysozyme may be of general occurrence in view of the wide distribution of O-acyl in bacterial cell walls (Park, J. T., unpublished observation, and see ref. 16). However, certain cells may use sugars as the blocking agent if one accepts that the essential feature of blocking is the covering of a particular hydroxyl group on the substrate.

Certain cells are essentially resistant to lysozyme possibly because they lack the lysozyme-sensitive bond (1-N-acetyl muramic acid—4-N-acetyl glucosamine). For example, *Staphylococcus aureus* H., which contains a considerable amount of O-acyl, is still resistant to lysozyme after removal of these groups. It is of interest to note that *Staph. aureus* produces a lysozyme-like enzyme, although presumably of different specificity, which enables rapidly growing cells under certain conditions to autodigest their cell walls whereas older cells cannot[17]. It is possible that before new cell wall can be synthesized a preliminary hydrolysis of part of the existing wall, by this enzyme, is necessary. Equally necessary would be a mechanism for protecting cell wall areas remote from this site. Substituents such as O-acetyl groups introduced into the cell wall polymer could clearly fulfil this function.

Various techniques such as those of Nakamura[18] and Repaske[19] are now available for inducing lysozyme sensitivity in a wide range of bacteria which under normal testing conditions are resistant to the enzyme. Whether or not these sensitivity changes are associated with hydrolysis of cell wall O-acyl groups is at present under investigation.

We wish to thank Miss J. A. Gathercole for excellent technical assistance.

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BIOLOGICAL EFFECT OF A MAGNETIC FIELD AND THE RADIATION SYNDROME

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As reported in a previous communication[1], when mice are kept in a homogeneous magnetic field of several thousand gauss, leucocytosis can be observed during the first weeks following the removal of the animals from the field. Both the segmented and the lymphocyte count increase and reach a maximum of 30–60 per cent in 12–14 days after removal of the animal from the magnetic field.

Based on these findings, the following working hypothesis was tested. Irradiation with X- or gamma-rays in the mid-lethal dose-range decreases the granulocyte and lymphocyte count in four or five days, to a few per cent of their normal value[2]. Since this effect of irradiation on the leucocyte count is, in its sign, opposite to that found after removal from the magnetic field, it could be expected that the bone-marrow syndrome in the radiation injury might be partly compensated, if irradiation and treatment in a magnetic field could be adjusted in a proper time sequence.

Eight-week-old virgin *RFM*-strain mice from the Roscoe B. Jackson Memorial Laboratory were used. From the 60 mice used in each experimental series, a sample of 10 or 20 of average weight distribution was selected, and placed for a period of 14 days in a magnetic field of 4,200 gauss. The maximum gradient of the field within the cage was 30 gauss/cm. The remaining mice were kept in standard plastic cages. 'Rockland mouse diet' and tap water were supplied *ad libitum* to both groups. At the end of the 2-week period the treated mice were placed for 2–3 days in standard cages, whereupon to all of them a whole-body irradiation was given in the Cobalt Therapy Unit of Cook County Hospital, at 57 r./min. intensity. All animals were deprived of food 10–12 hr. prior to irradiation to minimize intestinal syndromes[3].

In the following account the radiation dosage is always given for cobalt-60 gamma-rays; in order to convert the dosage to 250 kV. X-ray dosages of the same relative biological effectiveness, the values must be divided[4] by the factor 1·33. The expression 'controls' refers to animals irradiated but not treated in the magnetic field; and the expression 'treated' to animals which were treated in a magnetic field and irradiated.

Table 1 shows the irradiation dosage, the number and age of controls and treated mice at the time of irradiation, the mortality-rates and the probability-level in the difference of the mortality-rates.

In series *C*, the surviving 45 animals of series *B* were used again, and irradiated 44 days after their first irradiation. The same ten animals were treated anew, that is, kept for 14 days in a magnetic field prior to their (second) irradiation.

Table 1

Series	Dose	Age in days	No. of: Controls	No. of: Treated	Mortality-rate (per cent) Controls	Mortality-rate (per cent) Treated	Probability-level
A	850 r.	88	41	20	86	75	1:6
A'	850 r.	88	41	10	86	50	1:95
B	750 r.	77	50	10	30	0	1:107
C	850 r.	121	35	10	89	80	1:3·5

As it was shown by one of us, the development of young animals kept in a magnetic field is retarded. After magnetic treatment, the weight of the treated mice averaged 1–2 gm. less than that of their controls. Since, as is known, the irradiation mortality increases with decreasing body-weight, the treated animals were in a somewhat unfavourable situation. In series *A*, 10 of the heaviest mice from the 20 treated were marked. Their average weight was the same as that of the control group. The mortality-rate of this selected group is listed in Table 1 as series *A'*.

The difference in the mortality-rate between controls and treated mice is significant in series *A'* and *B*, but not significant in series *A* and *C*. It is highly significant for the pooled results of series *A*, *B* and *C* as well as for the pooled results of series *A'* and *B*.

In series *A*, blood samples were taken on the 5th, 10th, 15th, 20th and 30th post-irradiation days, from the tail veins of 6 controls and 6 treated. The segmented neutrophile and lymphocyte count dropped on the 5th day in treated and control groups to 3 and 2 per cent, respectively, of the original value. The upper part of Fig. 1 shows the change in the leucocyte count of the treated animals relative to the leucocyte count of the control group. The magnetic treatment does not compensate the leucopænia of the bone-marrow syndrome, but diminishes it by a percentage. Furthermore, it enhances the leucopænia between the 15th and 18th post-irradiation days. In view of these findings, it is not to be expected that magnetic treatment will decrease considerably the mortality-rate of the radiation injury of young mice in the high lethal range.

A significant difference is manifested in the mortality histograms. On the 9th, 10th, 11th and 12th day after irradiation, none of the treated animals

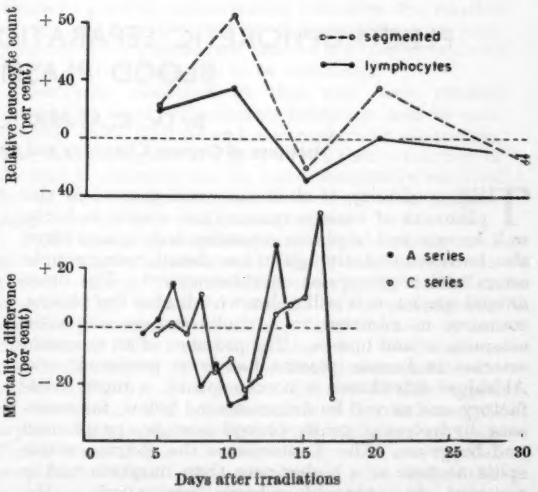

Fig. 1. Upper curves, leucocyte count of treated animals relative to controls; lower curves, mortality of treated above controls as a percentage of preceding-day survivors, for series *A* and *C*

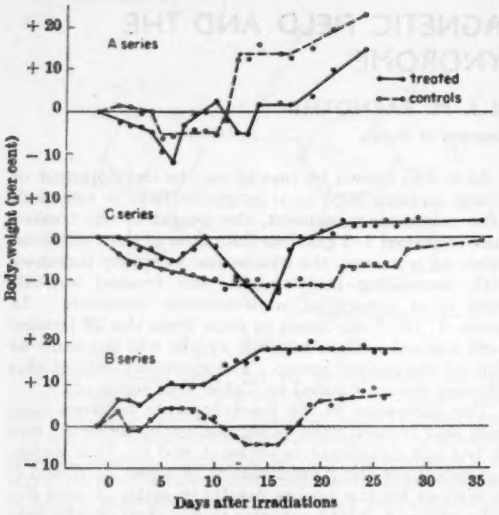

Fig. 2. Change in average body-weight relative to average body-weight on the day before irradiation for series *A*, *C* and *B*

died in either of the series *A* or *C*, although during the same period the highest toll was taken from the control groups. The lower curve in Fig. 1 shows the difference in the mortality-rate of treated and controls. This curve runs definitely anti-parallel to the relative leucocyte count (upper curves).

The body-weight of the animals was measured daily. Fig. 2 shows the change in the average body-weight for treated and controls in series *A*, *C* and *B*. The greater increase in weight after recovery in series *A* and *B* is due to the circumstance that in these series very young animals which were not fully developed were used. All three series show different behaviour of treated and controls. In both high-lethal series *A* and *C*, the weight curve of the treated shows a maximum on the 9th post-irradiation day, which coincides with the maximum in the relative leucocyte count in Fig. 1 and with the low-mortality period of the treated groups in series *A* and *C*. The weight-curves of the controls do not show such a maximum.

The weight-curve of the treated group in the low-lethal series *B*, although indicating a small minimum on the third day, increases thereafter continuously. This pattern of the weight-curves indicates that radiation injury was practically fully compensated in this low-lethal series through previous magnetic treatment. None of the treated mice died in this series.

A further effect of the magnetic treatment is indicated in the relative weight of spleens. (Spleens were removed and weighed within 2 hr. after death had occurred.) In series *A* the average spleen weight of treated and controls was the same. In series *C*, where the animals underwent a previous irradiation 44 days earlier, the spleen weight of the treated was only 57 per cent of that of the controls. The difference is significant on a probability-level less than $1/10^8$; and indicates that the treated animals were not affected by their first, low-lethal irradiation 44 days earlier and, therefore, their spleens did not pass through a transitory hyperplasia[5] as a consequence of the recovery process from leucopænia.

The hæmatological counts were made by Miss M. Walker at St. Francis Hospital, Evanston, Illinois. Acknowledgment is due to the staff of the Cook County Hospital, to Dr. I. F. Hummon, Dr. M. F. Magalotti and Miss D. Scully for their kind co-operation in the irradiation of the animals. The experiments were performed in our laboratory in Evanston, Illinois, and assisted by the Dorothy Shattuck-Stensland Foundation.

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ELECTROPHORETIC SEPARATION AND CLASSIFICATION OF BLOOD PLASMA ESTERASES

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THE specificity of cholinesterases present in the plasmata of various mammalian species is fairly well known and aliphatic esterases and lipases have also been studied, though in less detail, using simple esters and triglycerides as substrates[1–3]. For most animal species, it is still unknown whether the plasma contains, in addition to a cholinesterase, aliphatic esterases or/and lipases. The presence of an aromatic esterase in human plasma has been proposed[4] and Aldridge[5] introduced a nomenclature, a most satisfactory one as will be demonstrated below, for esterases hydrolysing *p*-nitrophenyl acetate, propionate and butyrate. The A-esterase is the enzyme which splits acetate at a higher rate than butyrate and is resistant to organophosphorus compounds; the B-esterase is inhibited by such compounds. It is not known, however, whether A- or/and B-esterases have the ability to hydrolyse aliphatic substrates or whether it is justifiable to call either A-esterase or both A- and B-esterases 'aromatic esterases'. Like the aliphatic esterases, they differ from the cholinesterases in being resistant to physostigmine.

Except for a study of the A- and B-esterases of rabbit and guinea pig plasmata[6], no attempt has been made so far to separate the various esterases electrophoretically. The object of the present investigation was to explore the usefulness of electrophoresis for such separations, to compare the esterase patterns of various vertebrate plasmata, and to propose a classification based on such patterns. The results showed that vertebrate plasmata contain three types of esterases; some plasmata contain all three types, others two and still others only one. When designating these enzymes, the nomenclature generally

accepted by most authors in this field was followed so far as possible. The characteristic features of these esterases as revealed by the present study are summarized below; it will be understood that within each group there are species variations in the properties of the individual enzymes within the group.

A-esterases (arylesterases): typical aromatic esterases which hydrolyse phenyl acetate at a higher rate than phenyl butyrate: aliphatic esters are normally not attacked. They are resistant to both organophosphorus compounds and physostigmine, and have, in most cases, the greatest electrophoretic mobility of the three esterase groups, moving together with or close to the albumin components.

B-esterases (aliphatic esterases, lipases): both aliphatic and aromatic esters are hydrolysed; there exist acetyl-, propionyl- and butyryl-B-esterases, and choline esters are not hydrolysed. They are sensitive to organophosphorus compounds, but resistant to 10^{-5} *M* physostigmine; some B-esterases are sensitive to higher concentrations of the latter compound. The B-esterases move electrophoretically more slowly than the A-esterases (eel plasma is an exception), but more rapidly than the C-esterases; they are always found in the α_1-globulin fraction or a fraction close to that component.

C-esterases (cholinesterases): choline esters are split at a higher rate than both aliphatic and aromatic esters, the latter usually being hydrolysed at a lower rate than aliphatic esters or not at all; the specificity regarding the acyl group varies greatly. These esterases are sensitive to both organophosphorus compounds and physostigmine, the latter giving 100 per cent inhibition in 10^{-5} *M* or lower concentration. They have the slowest electrophoretic mobility of all plasma esterases (frog plasma is an exception), normally migrating between the α_2- and β-globulins. (It is not my intention to add a new term to all those already existing for these enzymes; 'C-esterase' is used here only for practical reasons when these esterases are discussed in relation to the A- and B-esterases, and because it is the third esterase coming out in electrophoresis.)

Plasma was prepared from heparinized blood, and was free from all cells, including thrombocytes. Aliphatic, aromatic and choline esters were tested as substrates. The substrates used were the acetyl (Ac), propionyl (Pr), butyryl (Bu) esters of the following radicals, *iso*-amyl, glycerol (for example, tributyrin), phenyl and choline; also, acetyl-β-methylcholine, benzoylcholine, succinylcholine, the carbon analogue of acetylcholine (3,3-dimethylbutylacetate), 'Tween 20' (polyoxyethylene sorbitan monolaurate), procaine hydrochloride, atropine sulphate, cocaine hydrochloride, and heroin. Choline esters were all as iodides. Eight compounds were selected as inhibitors from those frequently studied as selective enzyme inhibitors[7] in recent esterase studies: physostigmine salicylate, tetra-*iso*propylpyrophosphoramide, mipafox (*bis*-mono*iso*propylamino fluorphosphine oxide), 'Astra 1397' (10-(1-diethylaminopropionyl) phenothiazine hydrochloride), 3318*CT* (*bis*-(piperidinomethyl coumaranyl-5)ketone), 62*C*47 (1,5-*bis*(4-trimethylammoniumphenyl)pentane-3-one diiodide), atoxyl, and quinine sulphate. The active fractions obtained in electrophoresis were dialysed against a bicarbonate buffer prior to testing against the inhibitors.

Electrophoresis was carried out on cellulose columns[8] (3 cm. × 40 cm.) in veronal buffer (*p*H 8·4, $\mu = 0{\cdot}1$) at 5–11° C., using 5 ml. buffered plasma for each experiment and a current of 60 m.amp.; the duration of runs was 30 hr. The protein concentration of successive 2·8 ml. fractions of the eluate was estimated by a modified Folin method[9], and the esterase activities of the fractions estimated manometrically by the Warburg technique[7].

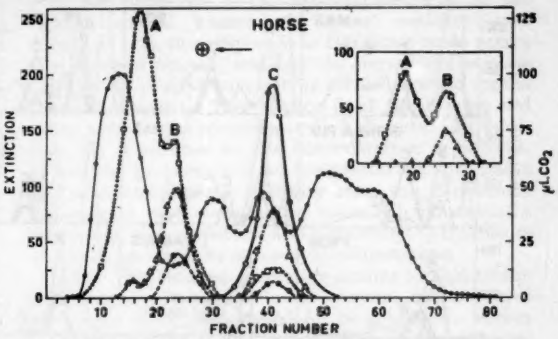

Fig. 1. Distribution of protein and esterase activity after column electrophoresis of horse plasma. The protein content (measured by the extinction at 700 mμ) and esterase activity (expressed at μl. carbon dioxide/30 min./ml. fraction) are plotted as ordinates against the fraction numbers as abscisse. For convenience in presentation, the esterase activities have been multiplied by the factors, shown below in brackets, before plotting. ○—○, protein concentration; □ . . . □, phenyl acetate (0·05); △-.-△, phenyl butyrate (0·1), tripropionin (0·15, peak *B*; 0·3, peak *C*); ●- - -●, tributyrin (0·1), *iso*-amyl butyrate (0·1, peak *B* only); ○–○, butyrylcholine (0·1), propionylcholine (0·16), benzoylcholine (0·8).
The insert is the electropherogram of a mixture of 3·8 ml. purified A-esterase and 8·0 ml. purified B-esterase from the peak fractions of *A* and *B*, main diagram, showing clearer resolution of A- and B-esterases. □ . . . □, phenyl acetate (0·4); △–·–△, phenyl butyrate (0·4)

Fig. 1 shows in detail the results of a single separation using horse plasma. It will be seen that, depending on the substrate, esterase activity was maximal in one or more of three clearly separated fractions. The three peaks of activity are designated *A*, *B* and *C*. It is a reasonable inference that these three peaks are due to the presence of three distinct enzymes, each with a different, and characteristic, electrophoretic mobility. The family of curves in each peak gives the substrate specificity of the enzymes responsible for it; a comparison of the esterase peaks with those of protein concentration indicates the relation of the enzyme proteins to the main protein components of the plasma and enables the specific activity of the various fractions to be estimated.

Esterases separated in this way were studied further by means of selective inhibitors and by submitting them to a second electrophoretic separation. The insert diagram in Fig. 1 shows that a mixture of A- and B-esterases can be more completely resolved by further electrophoresis and that each enzyme again travels as a single component.

Fig. 2 shows in simplified diagrams the results with nine further plasmata and Fig. 3 summarizes the plasma esterase pattern of all the species studied as revealed by combined studies of electrophoretic mobility, substrate specificity and sensitivity to inhibitors. The characteristics of the various plasmata studied will now be briefly summarized.

Horse (Fig. 1). This plasma contains all three types of esterases. The A-esterase is a typical acetylarylesterase, being resistant to all inhibitors studied. The B-esterase has a low specificity, and is a typical propionylesterase, the propionates in both the aromatic and aliphatic series of substrates being hydrolysed at a higher rate than the corresponding acetates and butyrates. It differs from most B-ester-

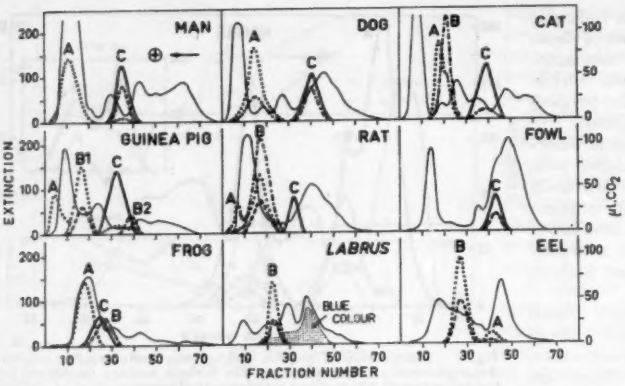

Fig. 2. Distribution of protein and esterase activity after electrophoretic separation of vertebrate plasmata. Conditions as for Fig. 1

Man: *A*, ..., phenyl acetate (0·01), phenyl butyrate (1·0). *C*, ——, butyrylcholine (0·1); – – –, tributyrin (0·4), phenyl butyrate (0·1), benzoylcholine (0·8); ....., phenyl acetate (0·01).

Dog: *A*, ..., phenyl acetate (0·025); –·–·, phenyl butyrate (0·4). *C*, ——, butyrylcholine (0·4); propionylcholine (0·8); –·–·, phenyl butyrate (0·4).

Cat: *A*, ..., phenyl acetate (0·01). *B*, –·–·, phenyl butyrate (0·1), tripropionin (0·2); ....., phenyl acetate (0·01). *C*, ——, butyrylcholine (0·4), propionylcholine (0·65); –·–·, phenyl butyrate (0·1).

Guinea pig: *A*, ..., phenyl acetate (0·05). B_1 and B_2, ..., phenyl acetate (0·05), phenyl butyrate (0·05; N.B. –·–·); tributyrin (0·07); tripropionin (0·07); 'Tween' (0·03); – – –, *iso*-amyl butyrate (0·2), ethyl acetate (0·2; peak B_1 only). *C*, butyrylcholine (0·2), phenyl butyrate (0·2); ....., phenyl acetate (0·05), tributyrin (0·07).

Rat: *A*, ..., phenyl acetate (0·05). *B*, –·–·, phenyl butyrate (0·05); ....., phenyl acetate (0·05); – – –, tripropionin (0·1), *iso*-amyl acetate (0·32), 'Tween' (0·2). *C*, ——, propionylcholine (0·8), butyrylcholine (1·0), phenyl acetate (1·0), phenyl butyrate (4·5).

Fowl: *C*, ——, propionylcholine (0·4); – – –, tripropionin (0·4), phenyl acetate (0·4), phenyl butyrate (0·4).

Frog: *A*, ..., phenyl acetate (0·02), phenyl butyrate. *B*, – – –, tripropionin (0·2), phenyl butyrate. *C*, ——, butyrylcholine (0·2).

Labrus: *B*, ..., phenyl butyrate (0·05), 'Tween' (0·2); – – –, tripropionin (0·1); shaded area refers to the blue-coloured fractions measured spectrophotometrically at 645 mμ.

Eel: *B* and *A*, ..., phenyl acetate (0·005), *iso*-amyl butyrate (0·15), triacetin (0·05); – – –, heroin (0·1).

ases in being resistant to tetra-*iso*propylpyrophosphoramide (but not to mipafox); this is characteristic also of the B-type esterases present in fish plasmata. The C-esterase is a typical butyrylcholinesterase with the same low specificity and similar inhibition pattern as that of human plasma. Phenyl acetate and phenyl butyrate are both split by all three esterases, the relative rates of hydrolysis by the A-, B- and C-esterases being 1·8 : 1 : 0·2 for the acetate and 1 : 5 : 4 for the butyrate. It will be seen that the A- and B-esterases migrate between the albumin and α_1-globulin components and the C-esterase between the α_2- and β-globulins.

Man (Fig. 2). Only A-esterase and C-esterase are present. The former hydrolyses phenyl acetate at a rate which is approximately 100 times greater than the hydrolysis-rate of phenyl butyrate; the enzyme is resistant to all inhibitors studied in this series and does not hydrolyse aliphatic esters. The C-esterase is a typical butyrylcholinesterase with low specificity, that is to say, the butyrates of both phenol and aliphatic alcohols (including glycerol) are split at relatively high rates. This enzyme is also capable of hydrolysing benzoylcholine and succinylcholine, as well as the carbon analogue of acetylcholine, procaine, atropine, and 'Tween 20'. It is sensitive to all inhibitors, physostigmine being the most potent compound (pI_{50} 7·7), and 62*C*47 and quinine the less potent ones (pI_{50} 5·0).

Dog (Fig. 2). The esterase pattern of this plasma closely resembles that of human plasma, in the first place by being devoid of B-esterase. The A-esterase is a typical acetyl-arylesterase, and the C-esterase is a butyrylcholinesterase of low specificity; the triglycerides are split at comparatively low rates. The C-esterase is otherwise similar to other butyrylcholinesterases present in the plasmata of various animal species.

Cow. An acetyl-A-esterase is the only esterase present in significant amounts. The plasma does not contain any B-type esterase, and the C-esterase, present in low concentration, is a propionylcholinesterase which is inhibited by excess substrate concentration. This enzyme is sensitive to those compounds (62*C*47 and 3318*CT*) which are regarded as being selective inhibitors of acetylcholinesterase (of erythrocytes and nerve tissue), and resistant to 'Astra 1397'.

Pig. The plasma has low, medium or high esterase activity, due mainly to the great individual variation in acetyl-arylesterase concentration. A B-esterase is probably not present. The properties of the C-esterase, also present in low concentration, differ from all other cholinesterases studied in this series regarding specificity, confirming previous results[3,10]; it does hydrolyse benzoylcholine, which has been a subject of discussion, and its sensitivity to inhibitors is otherwise similar to that of butyrylcholinesterases.

Cat (Fig. 2). Three esterases are present, of which the A-esterase is a propionyl-arylesterase. The B-esterase splits a variety of esters, the hydrolysis-rates being greatly dependent on the configuration of the alcoholic group; tripropionin is split at a higher rate than tributyrin, the reverse being true for the *iso*-amyl derivatives. The C-esterase is a butyrylcholinesterase similar to the human and horse C-esterases, except for being less sensitive to atoxyl and quinine.

Guinea pig (Fig. 2). Both A- and B-esterases are present in high concentration. The propionates and butyrates are split by the B-esterase at about the same rate, and more rapidly than the acetates. The

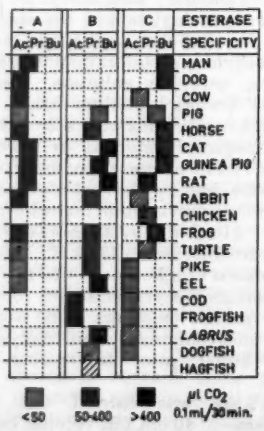

Fig. 3. Plasma esterase patterns of vertebrates

hydrolysis of 'Tween 20', the rate of which is comparatively high with this plasma, is catalysed by this enzyme. Guinea pig plasma also contains a second B-esterase (B 2), moving at a higher rate in electrophoresis than the C-esterase, and being sensitive to tetra-*iso*propylpyrophosphoramide but not to physostigmine. Both B-esterases are capable of hydrolysing *iso*-amyl butyrate. This ester is not split by the C-type esterase, which is a butyrylcholinesterase. It will be noted that all four esterases traced on the electropherogram are able to hydrolyse phenylacetate.

Rabbit. This plasma contains at least three esterases. Phenyl acetate and phenyl butyrate are hydrolysed by both an A-esterase (or probably two A-type esterases, running close together in electrophoresis) and a B-esterase; the latter enzyme has the properties of a propionylesterase and its concentration varies considerably from animal to animal. The C-esterase is an acetylcholinesterase (of a type found in the erythrocytes and nervous tissue). The properties are similar to those of such an enzyme in the following ways: splitting acetylcholine and propionylcholine at a higher rate than butyrylcholine; in being resistant to 'Astra 1397', atoxyl and quinine; in being less sensitive to tetra-*iso*propylpyrophosphoramide and mipafox than most other plasma cholinesterases, and very sensitive to 62*C*47; in that the activity is inhibited by high concentrations of acetylcholine.

Rat (Fig. 2). The esterase properties are very much like those of guinea pig plasma; the second B-esterase present in the latter plasma is, however, missing in rat plasma. The rat is the only mammalian species studied in this series which has a typical propionylcholinesterase in its plasma, confirming a previous observation[3]. In some respects, concerning inhibitory effects of various compounds, this enzyme differs from the butyrylcholinesterases.

Fowl (chicken; Fig. 2). This plasma is unique among those examined in being devoid of both A- and B-esterases. The B-type esterase described by Aldridge[5] is actually identical with the propionylcholinesterase present which splits acetyl-β-methylcholine at a comparatively high rate. The hydrolysis-rates of four different substrates, propionylcholine, tripropionin, phenyl acetate and phenyl butyrate, were all found to be influenced to the same degree by the eight inhibitors tested. The enzyme is extremely sensitive to mipafox pI_{50} 9·0) and is more or less resistant to 62*C*47, 3318*CT*[11], atoxyl and quinine.

Frog (*Rana temporaria*; Fig. 2). A-, B- and C-esterases are present, the A-esterase having similar properties to other plasma A-type esterases studied. The B-esterase differs from other B-type esterases in being somewhat sensitive to physostigmine (pI_{50} 4·5). Choline esters, however, are not hydrolysed by this enzyme, the C-esterase present being responsible for this reaction. The C-esterase is a propionylcholinesterase which splits butyryl choline at a relatively high rate, but differs otherwise from the C-esterase of chicken plasma. The most significant property of frog C-esterase is its relatively high electrophoretic mobility, higher than that of the B-esterase. The plasma of the toad, *Xenopus laevis*, contains an A-esterase, a propionyl- or/and butyryl-B-esterase, and a butyrylcholinesterase (in low concentration).

Eel (*Anguilla anguilla*; Fig. 2). This plasma is characterized by its ability to split aromatic esters and triglycerides (especially those of butyric acid) at a very high rate. The material seems to be the richest animal source of 'lipase' activity ever described; in this respect it is 100 times more active than human plasma, and has the same high esterase activity for phenyl butyrate as certain electric organs for acetylcholine. The enzyme is of the B-type and splits heroin at a comparatively high rate. In addition, an A-esterase in low concentration is present. It has the properties of an acetylesterase, and has a higher electrophoretic mobility than the B-esterase. Eel plasma also contains, as most fish plasmata, a C-esterase, the properties and sensitivity to inhibitors of which are those of an acetylcholinesterase.

Pike. The esterase pattern is similar to that of the eel plasma, except for lower enzyme activity and specificity more pronounced for propionates; heroin is hydrolysed at a low rate. Most of the esterase activity is due to a B-esterase, which is very sensitive to mipafox (pI_{50} 9·1) and less so to physostigmine (pI_{50} 4·8). The C-esterase, present in low concentration, is an acetylcholinesterase.

Cod. A B-esterase of the acetyl type is characteristic of this plasma. It splits heroin at a comparatively high rate and is sensitive to mipafox but not to tetra-*iso*propylpyrophosphoramide. An acetylcholinesterase is also present in low concentration.

Frogfish (*Lophius piscatorius*). The B-esterase, present in high concentration, is a typical acetylesterase which splits heroin at a high rate. It is sensitive to mipafox but not to tetra-*iso*propylpyrophosphoramide, and is also inhibited by physostigmine (pI_{50} 4·0). An acetylcholinesterase is present in low concentration.

Wrass (*Labrus berggylta*; Fig. 2). The B-esterase present splits butyrates and propionates at a higher rate than acetates, and is sensitive to mipafox but not to tetra-*iso*propylpyrophosphoramide. 'Tween' is split at a relatively high rate by this enzyme. The C-esterase, of low concentration, is an acetylcholinesterase. The blue colour characteristic of the labride plasmata is due to the presence of a chromoprotein (absorption maxima at 390, 600 and 645 mμ) which moves electrophoretically at a higher rate than other proteins present.

Dogfish (*Squalus acanthias*). The plasma has a very low esterase activity, being due to a propionyl-B-esterase and an acetylcholinesterase.

Hagfish (*Myxine glutinosa*). This plasma contains an esterase (probably an acetyl- or propionyl-B-esterase) in trace amounts. No other esterases have been detected.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Formaldehyde as an Acceptor Aldehyde for Transketolase, and the Biosynthesis of Triose

The enzyme transketolase is biologically widely distributed, and, in presence of thiamine pyrophosphate and magnesium ions, transfers the ketol group or 'active glycolaldehyde' ($CH_2OH.CO\ldots H$) from a variety of ketose phosphates (sedoheptulose 7-phosphate, D-fructose 6-phosphate, D-xylulose 5-phosphate), from certain free ketoses (L-erythrulose, D-xylulose) and from hydroxypyruvic acid to certain 'acceptor aldehydes', thus synthesizing new ketoses. The 'acceptor aldehydes' hitherto recognized are D-glyceraldehyde 3-phosphate, D-ribose 5-phosphate, D-erythrose 4-phosphate and 2-deoxyribose 5-phosphate; also free glyceraldehyde and glycolaldehyde (for reviews see refs. 1–3). Acetaldehyde and formaldehyde are stated not to be acceptors[4], but the former appears in our preliminary tests to be weakly active.

Formaldehyde, on the other hand, we find reacts quite effectively as an acceptor when pure lithium hydroxypyruvate[5] is the donor. The product formed corresponds chromatographically, chemically and enzymically with dihydroxyacetone:

$$CH_2OH.CO.COOH + H.CHO \rightarrow CH_2OH.CO.CH_2OH + CO_2$$

Table 1 shows the manometric and other results. Table 2 shows the chromatographic identification.

Table 1. Formaldehyde as 'Acceptor' for Transketolase Action

Transketolase was prepared by the method of de la Haba, Leder and Racker (ref. 4); a sample purified by column adsorption kindly supplied by Dr. E. Racker behaved similarly. Contents of vessels: transketolase (500 μgm.), thiamine pyrophosphate (0·2 μmole), magnesium chloride (5 μmoles), pH 6·6 buffer to total volume of 2·5 ml. Substrates as below (formaldehyde or hydroxypyruvate, 20 μmoles of each). The values given are in μmoles after 2 hr. incubation at 37° C.

Substrate	Hydroxypyruvate	Hydroxypyruvate + formaldehyde	Hydroxypyruvate + formaldehyde (no enzyme)
Carbon dioxide produced	1·2	15·2	0
Formaldehyde utilized	0	15·7	0·8
Hydroxypyruvate utilized*	2·6	18·0	2·8
Triose formed†	none	+++	none

* Spectrophotometrically by specific dehydrogenase (cf. ref. 11).
† By glycerokinase and adenosine triphosphate (manometrically and also by formation of alkali-labile phosphate); by formation of methyl glyoxal on distillation with acid; and by chromatography (Table 2).

Table 2. Chromatographic Identification of Dihydroxyacetone Formed

Deionized vessel-contents (Table 1) were concentrated *in vacuo* and analysed by descending chromatography on Whatman No. 1 paper; detection by aniline phosphate spray

Solvent (parts by vol.)	*Rf* values: Unknown	Dihydroxyacetone	Glyceraldehyde	Erythrulose	Threose
Phenol/water (4 : 1)	0·81	0·81	0·44	0·72	0·65
Butanol/acetic acid/water (4 : 1 : 5)	0·45	0·45	0·49	0·36	0·43
Ethylmethyl ketone/acetic acid/4 per cent boric acid (9 : 1 : 1)	0·48	0·49	0·14	0·38	0·36

The interaction of transketolase with the numerous biological sources of formaldehyde opens the possibility of various new metabolic routes. The dihydroxyacetone formed in the above reaction is readily phosphorylated by 'glycerokinase' prepared from rat liver by the method of Bublitz and Kennedy[6]: the resulting phosphate could therefore enter the triose phosphate and hexose phosphate pools. Another route from L-serine to hexose, alternative to that proposed for phosphoserine by Ichihara and Greenberg[7], might proceed via serine aldolase (giving formaldehyde and glycine) in conjunction with the formation of hydroxypyruvate from L-serine by the specific transaminase of Sallach[8]. Transketolation of the hydroxypyruvate to formaldehyde could thus provide dihydroxyacetone. Whether the observed transformation in the rat of [3-^{14}C]serine[9] and of [2-^{14}C and 3-^{14}C] hydroxypyruvate[10] to liver glycogen actually follows this pathway is being investigated. The extent of formation of dihydroxyacetone from donors other than hydroxypyruvate and the question of reversibility of these reactions are also being studied by us.

Thanks are due to Mr. R. Carrick James for technical assistance.

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A Procedure for the Purification of Sirenin

Sirenin (I am indebted to Dr. A. Vegis for suggesting, what seems to me, this aptly descriptive name) is the name, used here for the first time, for the chemotactic sexual hormone from the water-mould *Allomyces* which attracts the male gametes and is produced by the female gametes[1]. This hormone has now been produced and purified.

Fernbach flasks (1,800 ml.) containing 500 ml. of yeast extract–starch medium[2] were inoculated with mycelial fragments of the female strain *F*-2[1] and incubated for two days on shakers at 30° C. The plants obtained were washed with copious amounts of tap water and then placed in thin layers in dishes where they were just covered with double-distilled water. This water was replaced after 3, 8 and 24 hr., thereby inducing gamete formation and release for a total of 48 hr. The aqueous solutions, containing approximately 25–100 μgm. sirenin per litre, were freed of gametes by passage through Seitz filters and the solutes adsorbed on 'Norit *FNX* Special' charcoal used at the rate of 5 gm. per 500 ml. of solution.

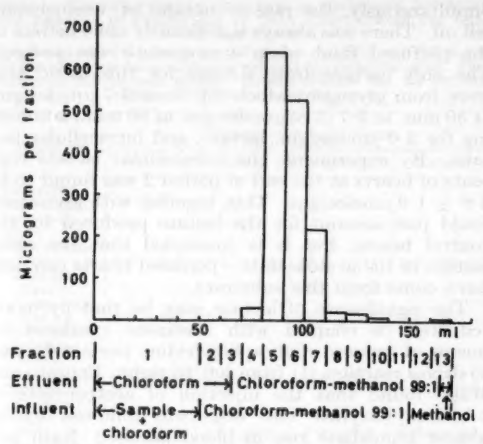

Fig. 1. The fractionation of sirenin on a silicic acid column

The solutes were eluted from the charcoal with chloroform, evaporated to dryness at room temperature, and the residue then extracted with water. Upon removing the water at 30° C., the residue was taken up in 3–10 ml. of redistilled chloroform, thereby providing the sample for fractionation on a silicic acid column[3]. The programme followed and the fractionation obtained are shown in Fig. 1. The last addition was followed by 50 ml. of chloroform to prepare the column for the next run.

The details of this procedure for purifying sirenin were clarified shortly before this investigation had to be terminated. Consequently, the various small samples in the laboratory were each passed through the column; fractions 1, 12, and 13 were discarded and the remaining fractions from all runs mixed and re-run. Fractions 5 and 6 of this final run (Fig. 1) were mixed, the solvent evaporated, and the residue analysed. A clearly detectable response in the bioassay[1] was observed with a concentration of 10 μgm. per litre. The fact that sirenin was not retained on 'Dowex' 2 and 50 ion exchange columns indicated that the molecule is neutral. Characteristic absorption peaks were absent from the ultra-violet spectrum.

The 6μ region of the infra-red absorption spectrum displayed a not very well resolved band consisting of several overlapping absorption bands. Of these bands, one at 5·63μ indicated the presence of a lactone ring, another at 6·85 indicated the presence of keto and/or aldehyde functions, and perturbances in the 5·95 to 6·03μ region suggested double-bond carbon and/or carbon–nitrogen functions. There was no evidence of aromatic rings and no positive indications of hydroxy and carboxyl functions.

The mass spectrum showed no very distinctive characteristics. However, peaks corresponding to *m/e* 31, 44, and 58, which often reflect ionized fragments representing methoxy, aldehyde and unsubstituted ketone (— CH_2COCH_2 —), respectively, were stronger than to be expected unless such groups were actually present in the molecule. There was in this spectrum, too, no indication of aromatic rings. The maximum molecular weight indicated by the mass spectrum was 386.

The ultra-micro[4] elementary analysis was consistent with the preceding inferences. There was found: C, 61·6 (± 1·5) per cent; H, 8·8 (± 0·3) per cent; N, 3·4 (± 0·3) per cent; and O (by difference), 26·2 per cent. On the basis of the formula $C_{21}H_{36}O_7N$ the minimum molecular weight is 414. This weight is of the same order of magnitude as that indicated by the mass spectrum. These tentative analyses are presented here since they may be useful to others in the determination of the structure of sirenin.

This work was performed in the Institute of Physiological Botany, University of Upsala, where I was on sabbatical leave, with the assistance of a fellowship from the John Simon Guggenheim Memorial Foundation, and was supported, in part, by a research grant (*G*1291) from the National Science Foundation.

I wish to acknowledge the assistance of the following: Prof. Nils Fries, whose guest I was at the Institute; Dr. A. Rosenberg for making and interpreting the infra-red spectra; Prof. P. E. Lindahl and his assistant for the ultra-violet spectra; Prof. E. Stenhagen and Dr. R. Ryhage for making and interpreting the mass spectra; and Mr. W. Kirsten for the ultra-micro elementary analysis. A more detailed report of this work is being published in *Physiologia Plantarum*.

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Formation of Lactate from Acetoacetate in the Perfused Heart

Seaman[1] and Davies[2] have recently described enzyme systems in protozoa and pig heart which catalyse the oxidative condensation of two molecules of acetyl coenzyme *A* to produce succinate.

$$2CH_3.CoSCoA + DPN^+ \rightarrow HOOC.CH_2.CH_2COOH + 2CoA + DPNH + H^+ \quad (1)$$

The existence of the enzyme in rat tissues is at present debatable[1]. The reaction is reversible, and, in fact, the equilibrium is very much in favour of cleavage of the succinate, but it may be driven in the direction of synthesis by the addition of suitable systems capable of oxidizing reduced diphosphopyridine nucleotide[2]. Since succinate may be transformed into pyruvate either through decarboxylation of oxaloacetate or oxidative decarboxylation of malate, reaction 1 is the key to a synthesis of carbohydrate from fat with net gain of carbon.

Recent experiments with isolated rat diaphragm in which the muscle was incubated with glucose and acetate or acetoacetate[3] have shown that significantly more lactate is produced, when acetoacetate is present, than can be accounted for by disappearance of glucose and glycogen. With acetate as substrate, lactate appearing exactly balanced the loss of carbohydrate. Since acetoacetate can be cleaved in muscle to acetyl coenzyme *A*, it was tentatively concluded that the pathway outlined above, followed by reduction of pyruvate to lactate, was operating in this tissue. The reason why net lactate synthesis took place from acetoacetate and not from acetate was thought to be the very high rate of uptake of the former compound.

Table 1. Hearts from Fasted Male Albino Rats perfused with Krebs–Ringer Bicarbonate

Three periods, volume in each period 20 ml. (first period, 1·5 mgm./ml. glucose; second period, no glucose; third period, no glucose ± acetoacetate, 0·01 *M*; concentration of sodium chloride in Ringer solution being reduced by 0·01 *M* when acetoacetate was present). 0·5-ml. samples removed from system at 10 min. intervals for estimation of lactate (ref. 5) and acetoacetate (ref. 6). The tabulated figures represent rates of lactate production ± standard deviation during each period; negative values indicate disappearance of lactate. A correction has been made for carry-over of lactate from one period to the next

Solution \ Time	50–60 min.	60–70 min.	70–80 min.	Final glycogen (μmole/gm.)
	Lactate produced (μmole/gm./hr.)			
Control (10)	6·9* ± 4·9	−1·8 ± 3·9	−0·8 ± 3·2	2·7 ± 1·3
Acetoacetate (10)	18·1* ± 14·4	3·0 ± 12·7	−7·6 ± 11·1	2·8 ± 0·7
	Acetoacetate utilized (μmole/gm./hr.)			
Control	—	—	—	*t = 3·18
Acetoacetate	32·1 ± 15·5	26·7 ± 21·8	21·4 ± 16·9	P < 0·01

The results were not, however, beyond doubt, in that proof of the formation of 'excess' lactate depends on the determination of the uptake of glucose, initial glycogen-content, final glycogen-content and lactic acid production, all of which values are subject to error. It was decided to repeat the experiments with a system which could be stripped of carbohydrate before adding the lactate precursor. The isolated perfused rat heart was found very suitable.

Hearts from fasted rats weighing 150–180 gm. were perfused, essentially according to the method of Bleehen and Fisher[4], in an apparatus which permitted the replacement of all the circulating perfusate when desired. Glucose was added to the perfusion fluid while the heart was being established; the fluid was then changed to one without glucose. After perfusion for 30 min. with this solution, the heart glycogen, which was initially 20·6 ± 4·2 μmoles/gm., had fallen to 3·7 ± 1·6 μmoles/gm. (mean values), and lactate had ceased to enter the perfusion fluid. There was indeed evidence of a slow disappearance of lactate, presumably by oxidation, towards the end of the period (Fig. 1). A second group of hearts was perfused for three periods: for 20 min. with Ringer + glucose; for 30 min. with Ringer − glucose; and for 30 min. with Ringer − glucose ± acetoacetate (0·01 *M*). The results are shown in Table 1.

Six of the ten hearts perfused with acetoacetate produced significantly more lactate during the first 10 min. of period 3; the average production for the whole group was 11·2 μmole/gm./hr. more than ten controls. Production fell off during the next 20 min. and a slow disappearance of lactate began (Fig. 1).

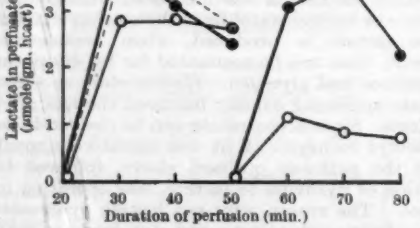

Fig. 1. Production of lactate by perfused hearts: perfusate changed at 20 and 30 min. ○—○, Control; ●—●, acetoacetate in period 3; ●– – –●, hearts stopped at 50 min.

Simultaneously, the rate of uptake of acetoacetate fell off. There was always significantly more lactate in the perfused fluid when acetoacetate was present. The only carbohydrate sources for this lactic acid were from glycogen, which fell from 3·7 μmoles/gm. at 50 min. to 2·7 (2·8) μmoles/gm. at 80 min., accounting for 2·0 μmoles/gm. lactate, and intracellular lactate. By experiment, the intracellular lactate contents of hearts at the end of period 2 was found to be 4·8 ± 1·9 μmoles/gm. This, together with glycolysis, could just account for the lactate produced by the control hearts, but it is concluded that the extra lactate in the acetoacetate – perfused hearts can only have come from this substrate.

The significance of lactate may be that pyruvate reduction is coupled with succinate synthesis by means of reduced diphosphopyridine nucleotide, and so drives reaction (1) from left to right. Capraro and Milla[7] found that the injection of acetoacetate or β-hydroxybutyrate into dogs was followed by an almost immediate rise in blood lactate; Nath and Chakrabarti[8] reported that daily injection of acetoacetate over a period of time caused a gradual rise in the blood lactate-level in rabbits. In the present experiments, perfusion with acetoacetate did not alter the glycogen content of the hearts, so that there was no direct synthesis of glucose from acetoacetate in the muscle itself; it appears to be generally agreed that the heart cannot synthesize glycogen from exogenous lactate[9] at least. However, in the intact animal, glycogen can be synthesized from lactate in the liver, so that a synthesis of glucose from fat would be possible by means of a cycle running from liver to muscle to liver, in ketotic organisms. Recent experiments[10] on feeding high-fat diets to obese human subjects can be explained in these terms. Gluconeogenesis by such a mechanism can only be important, of course, in extreme conditions of starvation or diabetes when the level of ketone bodies in the blood is much above normal.

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Removal of Internally Deposited Plutonium

Attempts to remove plutonium from the mammalian system may be placed in two categories: (1) prevention of deposition by treatment within eight hours after exposure to plutonium and (2) removal of plutonium after it has become 'fixed' in the tissues. Zirconium citrate and ethylenediamine tetraacetic acid have been used with some success in the first category but with only limited success in removing firmly bound plutonium[1]. Among compounds tested in this laboratory, diethylenetriamine

Table 1. Effect of Chelating Agents on Plutonium Deposition and Removal as Percentage of Dose Administered per Gram of Dry Tissue

The dosage was 0·3 m.mole per rat of each material with 0·2 m.mole calcium gluconate being administered with the chelating agent. There were 6–10 rats in each group. Results include the 95 per cent confidence interval around the mean

Treatment	Concentration in the tissue			
	Bone	Liver	Spleen	Kidney
Category 1 (Prevention of deposition)				
Saline controls	6·6 ±0·5	9·1 ±1·4	18·0 ±2·0	2·4 ±0·1
Ethylenediamine tetraacetic acid	4·6 ±0·3	4·9 ±0·7	10·7 ±2·2	1·4 ±0·1
Diethylenetriamine pentaacetic acid	0·87±0·06	2·7± 0·3	2·4 ±0·3	1·6 ±0·2
Category 2 (Removal)				
Saline controls	7·8 ±0·9	1·8 ±0·4	2·9 ±0·6	0·60±0·13
Ethylenediamine tetraacetic acid	6·3 ±0·6	1·2 ±0·2	1·2 ±0·2	0·45±0·10
Diethylenetriamine pentaacetic acid	4·0 ±0·2	0·23±0·04	0·93±0·26	0·30±0·10

pentaacetic acid has proved to be superior in both categories.

Adult Sprague–Dawley rats were injected intravenously with about 1 μc. of plutonium as the citrate. A single, intraperitoneal treatment was administered 1 hr. after the plutonium in the category 1 experiment, whereas several treatments a week, beginning 38 days after the plutonium injection and running for four weeks, were given in the removal experiment. Rats in the category 1 experiments were killed two days after the plutonium injection, and in the long-term experiment on the sixty-fourth day.

As shown in Table 1, diethylenetriamine pentaacetic acid is consistently more efficient than ethylenediamine tetraacetic acid in eliminating plutonium. The prompt administration of the former reduced the skeletal plutonium content from 61 per cent of the administered dose in the controls to about 9 per cent, whereas animals treated with the latter retained 44 per cent of the administered dose. The relatively poor results obtaining by administering diethylenetriamine pentaacetic acid promptly in preventing deposition in the kidney may be due to the short duration of the experiment (two days), since in longer experiments it was more effective than ethylenediamine tetraacetic acid in removing plutonium from the kidney. Its effectiveness as a therapeutic agent is also indicated in the removal of firmly bound plutonium. The four-weeks treatment reduced the plutonium content of bone by about one-half, and also markedly reduced the plutonium content of soft tissues. It should be noted that these experiments are of a comparative nature and do not represent treatment at the maximum tolerated dose, which is about three times that used here.

A more detailed account of these and other studies on plutonium detoxification will be published elsewhere. I am grateful to B. D. Chubb and the other assistants of the Metabolism Operation for their help on these experiments. The diethylenetriamine pentaacetic acid was supplied through the courtesy of the Geigy Chemical Corporation, Ardsley, New York.

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Molecular Weight of Condensed Tannins as a Factor determining their Affinity for Collagen

Examination of the chemical principles of vegetable tanning[1] has led to various considerations of the nature of the bonds between tannin and collagen; to an examination of the possible 'active sites' of tannin fixation on the collagen chain, and to the quantitative study of tannin uptake in relation to the swelling of collagen[2]. The critical function of the different tannins normally present in any extract mixture in determining the quantitative and qualitative aspects of tannin affinity for collagen[3] was, however, largely overlooked in work emphasizing those important aspects listed above.

From a study of the relation between chromatographic behaviour and average molecular weight of 'condensed' tannin fractions, Evelyn and I (unpublished work) have recently found that in aqueous medium a gradational increase in molecular weight with decrease of R_F occurs over the ranges 550–3,200 for black wattle bark tannins (*Acacia mollissima*) and 790–2,350 for quebracho heartwood tannins (*Schinopsis* spp.). Similar behaviour also occurs in the 'partitioning' mixture *n*-butanol/acetic acid/water (6 : 1 : 2). We find, both under conditions of 'adsorption' and 'partition', that a linear relation exists between the average molecular weight of these typical 'condensed' tannin fractions and their R_M $\left(\text{defined as } \log\left(\frac{1}{R_F} - 1\right)\right)$ values.

I previously directed attention[3] to the parallel between the chromatographic behaviour of wattle tannin constituents on collagen columns and on paper chromatograms. These constituents also show the same relative affinities for various modified collagen substrates as for cellulose[4]. This similarity of behaviour of condensed tannins towards such widely differing substrates is further reflected in the low chromatographic affinities of catechins, flavan-3 : 4-diols (monomeric leuco-anthocyanins) and wattle 'polyphenolic non-tannins' for both collagen and cellulose, and also in the parallel increase in relative affinity resulting from the atmospheric oxidation of these substances[5]. This indicates the predominant effect of the nature of the tannins in determining their relative affinities for any substrate, in much the same way as the constitution of closely related dyes determines their affinity for cellulose and other natural materials[6,7].

The almost exact parallel between the relative affinities in aqueous medium (as reflected by 'adsorption' chromatographic behaviour) of condensed tannin constituents for cellulose, collagen and modified collagens, and the linear relation between

their R_M values on cellulose and their average molecular weights, suggest that a similar relationship also exists between the R_M values on collagen columns and molecular weight. This has been partly confirmed by Evelyn (unpublished work), who established a direct relation between the average molecular weight of wattle tannin fractions and the proportion of 'irreversibly fixed' tannins in leather tanned with these fractions. Page[8] has also shown that the stoichiometric relationship of the combination of gelatin with various wattle tannin fractions (obtained by fractional precipitation from aqueous solution with salt) varies from the least soluble to the most soluble fractions. The gradational decrease in the 'gelatin number' he surmised to be due to a decrease in the molecular weight of the tannins and, in relation to our more recent findings, it also emphasizes the importance of the tannins in determining the 'affinity' between tannin and collagen. Peters and Sumner[7] found a correlation between the molecular weight of aminoanthaquinones and their chemical affinities for cellulose. The lower affinity of monomeric leuco-anthocyanins and catechins (phenolic 'non-tannins'), compared with that of naturally occurring complex leuco-anthocyanins[9] and polymeric catechins[10] ('tannins'), for hide powder during estimation of tannin appears to be due to the low molecular weight of the former ($\pm$300) in comparison with the latter (550–3,200). Following atmospheric oxidation, other factors, for example, the presence of quinonoid groups, increase their affinity.

The relation between R_M and molecular weight suggests the operation of physical forces between tannins and cellulose or collagen. This appears to be in line with the increasing emphasis on the importance of van der Waals forces between cellulose and various solutes, such as dyes[7,11]. Tannin mechanisms are, however, exceptionally complex, and hydrogen-bond forces undoubtedly play an important part[12] in the swelling of the hide, in the sorption and de-sorption of tannins, and possibly also in their fixation to collagen.

On the basis of the above work, it has been found possible to use paper chromatography as a method of interpreting the relative affinities of wattle and quebracho tannins for collagen. Planar 'flavonoid' compounds, for example, flavones, flavanols, anthocyanidins, aurones and chalkones[8,13], are exceptions, due to their abnormally high affinity for cellulose in aqueous medium.

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Gas Chromatographic Separation of Meta- and Para-Xylenes in Aromatic Mixtures

The xylene isomers have resisted all previous attempts at resolution by gas-liquid chromatography. An approach to their separation was made recently by Scott and Cheshire[1], who used a column with a calculated efficiency of 12,000 theoretical plates. Indeed, the chromatogram showed a very slight separation for *meta*- and *para*-xylene.

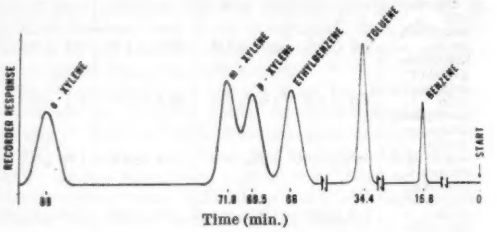

Fig. 1. Chromatogram of mixture of aromatics

The work reported here makes use of an aromatic hydrocarbon as the stationary liquid for effecting this difficult separation. Fig. 1 shows the resolution of a mixture of benzene, toluene, ethylbenzene, *ortho*-xylene, *meta*-xylene and *para*-xylene. Conditions for the separation were as follows:

Instrument	'Model 188' vapour fractometer
Column dimensions	5 m. × 5 mm.
Column temperature	100° C.
Stationary liquid	15 per cent w/w benzyldiphenyl (May and Baker Co.)
Column support	60–80 mesh 'Chromosorb' (Johns–Manville Co.)
Carrier gas	Helium
Carrier gas inlet pressure	59 lb./in.^{2}
Carrier gas flow	100 cm.^{3}/min.
Sample charge	0·005 ml.
No. of theoretical plates	9,500
Time of analysis	93 min.

The specificity of benzyldiphenyl and the high pressure-drop across the column permit the accomplishment of this separation in a reasonable time with columns of standard length and high efficiency. Sample sizes should, of course, be minimized.

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Crystal Structure of Chabazite, a Molecular Sieve

The 'molecular-sieve' properties of chabazite, a zeolite occurring in basaltic rocks, have been studied extensively. Molecules such as argon (diameter 3·84 A.) and methane (4·25 A.) are rapidly sorbed in the dehydrated zeolite; propane (width 4·9 A.) and *n*-butane are slowly sorbed, while *iso*-butane (5·6 A.) is excluded. A crystal structure was proposed by Wyart[1] in 1933, which consists of a three-dimensional framework of four- and six-membered rings of $(Si,Al)O_4$ tetrahedra (Fig. 1*a*). The rings form two cages per unit cell, the cages sharing six-membered rings which provide apertures of maximum dimension

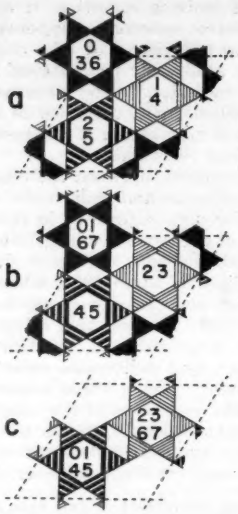

Fig. 1. Diagram to show stacking of six-membered rings of $(Si,Al)O_4$ tetrahedra in (*a*) Wyart's structure for chabazite, (*b*) the new structure for chabazite, (*c*) gmelinite. Different shading of the rings indicates different heights and the numerals represent the heights of the rings in which they occur, expressed as multiples of 2·5 A. In (*b*) and (*c*) each six-membered ring is linked directly to one immediately above or below it, forming hexagonal prisms. In (*a*) all linkages go outwards from the ring and hexagonal prisms are not formed. All the arrangements are idealized, especially in (*a*)

2·9 A. if the usual Si—O and Al—O distances are used, and 3·1 A. if the somewhat unusual distances in Wyart's structure are adopted. Although Kington and Laing[2] have interpreted the sorptive properties of chabazite in terms of Wyart's structure, the agreement can scarcely be regarded as satisfactory when a molecule of minimum dimension 4·25 A. passes easily through an aperture of diameter 2·9–3·1 A. As the structure of chabazite was proposed in the early days of crystal structure determination further investigation appeared desirable.

Using Fourier methods, a new structure has been determined which explains the X-ray intensities, the sorption and epitaxial intergrowth with the mineral gmelinite. The chabazite specimen contains two units of $(Ca_{0\cdot90}Na_{0\cdot18})$ $(Si_{4\cdot08}Al_{1\cdot95})_6O_{12}.6H_2O$ in a trigonal cell of symmetry $R\,\bar{3}m$ (or nearly so) and $a = 9\cdot40$ A., $\alpha = 94°\ 18'$. The positions of the silicon, aluminium and oxygen atoms are approximately :

Si,Al	0·34,	0·11,	−0·12
O_1	0·27,	−0·27,	0·00
O_2	0·17,	−0·17,	0·50
O_3	0·25,	0·25,	0·90
O_4	0·03,	0·03,	0·35

At the present stage of refinement, the distances (Si, Al)—O range from 1·63 to 1·68 A. and the O—O distances from 2·62 to 2·82 A., in excellent agreement with the standard values. From the positions of the silicon and aluminium atoms shown in Fig. 2 the nature of the framework may be seen. The new structure is built up of double six-membered rings (Fig. 1*b*) forming one 'cage' per unit cell. Each cage has six octagonal, two hexagonal and twelve quadrilateral faces, and is connected to the six neighbouring cages by eight-membered rings, permitting sorption in all directions, but limiting it by the octagonal (non-planar) apertures of minimum width about 3·9 A. Although the present work is being carried

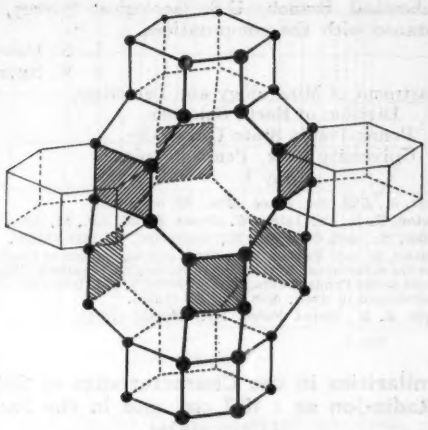

Fig. 2. The positions of the Si,Al atoms in chabazite. Shaded quadrilaterals represent points of attachment of hexagonal prisms, four of which are shown

out on a hydrated specimen and the cavities are filled with water molecules and calcium ions, the framework is expected to differ only slightly in the dehydrated state and the size of the aperture should not change by more than 0·2 A. When thermal vibration is considered, the new structure gives an excellent explanation of the observed sorptive properties. The co-ordinates of all the atoms are being refined by successive Fourier series, and results for a dehydrated chabazite held at 300° C. in a stream of nitrogen are being collected in order to determine the movements of the framework and the calcium atoms as a result of dehydration.

Further confirmation of the validity of the structure arises from the ready interpretation that may be placed on the chabazite-gmelinite intergrowths. It has been pointed out[3] that not only are the hexagonal *a*-axes of the two minerals identical and the *c*-axes in the ratio of 3 : 2 but also that the two form oriented intergrowths, with streaks parallel to *c* joining the reflexions. The *c*-axis projection of gmelinite has been determined by O'Daniel and Fischer[4] and idealized in Fig. 1*c*. The *z* co-ordinates were not given, but it seems likely that they are as shown. The relationship of the stacking of the double rings in chabazite and gmelinite would be of cubic to hexagonal close-packing, and the intergrowths and diffuse streaks would be the result of stacking faults.

Such a structure for gmelinite would have channels the narrowest parts of which were twelve-membered rings, and it would be expected that gmelinite would sorb some *iso*-paraffins and aromatics. Barrer[5], however, reports that its sorptive properties are similar to those of chabazite, which excludes *iso*-paraffins and aromatics. One possible explanation of this anomaly is that Barrer's specimen (for which no X-ray data or locality were given) may have contained intergrown chabazite, or have been somewhat disordered; for either of which, sorption would be mainly limited by the eight-membered rings of chabazite. A second possibility is that the sodium ions of gmelinite may partially block the apertures, reducing the effective channel to the size of that in chabazite.

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Similarities in the Characteristics of Solar Radiation at λ 10·7 cm. and in the Far Ultra-violet

Denisse and Kundu[1] have directed attention to the close relation between the variations of two indices of the solar cycle which represent the flux of two different types of solar radiation. The first index ($Ch_E = f^4 \sec \chi$) is based on the monthly mean critical frequency (f) of the E-layer at noon at Freiburg (Germany); it is assumed to be proportional to the flux of the ultra-violet and X-radiation of solar origin which is responsible for the atmospheric ionization at heights near 120 km. The second index is the monthly mean value (Φ) of the solar radio-noise flux at λ 10·7 cm., measured at Ottawa, which is available from February 1947 onwards. Denisse and Kundu conclude that the two types of radiation are produced, if not by the same mechanism, at least under closely correlated conditions.

We have recently examined the characteristics of a number of indices of solar activity including both Ch_E, calculated using E-layer data for Slough (England), and Φ. We have confirmed that the correlation between the two indices is high ($r = 0{\cdot}90$), but we have also found that it is even higher if the data for each month are considered separately ($r_{max.} = 0{\cdot}99$).

From Table 1, it can be seen that r is greater than 0·90, the value for all months taken together, in eleven out of twelve months. It may be inferred from this result that the correlation coefficient for individual months is significantly greater than that for all months considered together; the probability that the observed result occurred by chance is 3×10^{-3}.

The reason for the result just mentioned is that although the magnitude of Ch_E is controlled mainly by the flux of ionizing radiation, it also contains a small complicated seasonal component. For this reason, uncorrected values of Ch_E ought not to be assumed to be accurately proportional to the flux of the incident radiation. The seasonal component varies in amplitude with the level of solar activity, but a method of eliminating it has been devised and will be described elsewhere.

Table 1. Correlation Coefficient (r) between Ch_E (Slough) and Φ (Ottawa). February 1947–December 1956

Month	r
January	0·99
February	0·95
March	0·87
April	0·93
May	0·95
June	0·93
July	0·98
August	0·91
September	0·97
October	0·96
November	0·97
December	0·99
All months	0·90

A further similarity between the characteristics of the ionizing radiation and radio noise at λ 10·7 cm. is evident if the non-uniformity in the brightness of the Sun's disk at the two wave-lengths is studied when the disk is undisturbed. Such a study was possible during the eclipse of June 1954, when the Sun was unusually quiet and there were no localized active areas on the disk. During this eclipse, ionospheric measurements were made in the United Kingdom[2] and in Norway[3], and radio-noise measurements were made in Canada[4]. From these results it has been possible to make estimates of the relative brightness of the disk near the poles and near the east and west limbs, and the agreement between the ionospheric and the radio-noise results is quite striking[5] (Table 2).

Table 2. Relative Brightness of the East Limb of the Sun and the Polar Regions referred to the Centre of Disk (June 30, 1954)

Type of measurement	East limb	Poles
Ionosphere ($F1$ layer)	1·8	0·86
Radio-noise (λ 10·7 cm.)	1·5	0·91

The results summarized in Tables 1 and 2 appear to confirm the conclusion reached by Denisse and Kundu; but it is probably premature to speculate on the precise reasons for the observed similarities in the characteristics of the two types of radiation.

This work was carried out as part of the programme of the Radio Research Board, and this communication is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

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'Whistlers' in the Antarctic

'Whistlers' are being heard consistently at Scott Base, the New Zealand International Geophysical Year Antarctic Station, McMurdo Sound. From the time observations commenced on April 15 until the time of writing considerable activity has been observed, including 'bonks', 'tweeks', short and long 'whistlers', whistler trains, and periods of strong 'sferics'. No dawn chorus has yet been observed.

The geomagnetic co-ordinates of Scott Base are 79° 15′ S., 294° 30′ E. The base is located approximately 1,200 km. north-east of the geomagnetic pole and approximately 1,250 km. south-east of the dip pole. It is believed that this is the first time that whistlers have been heard in such a high geomagnetic latitude.

The whistlers appear to have dispersion characteristics similar to those heard in lower geomagnetic

latitudes. However, the characteristics cannot be truly determined until tape recordings of them are sent to New Zealand for spectrographic analysis, at the end of the Antarctic winter.

Maximum activity occurred on April 15, 16, 19, 20 and 23. No consistent diurnal variation in activity has been noted. On all occasions of strong whistler activity the local geomagnetic activity has been moderate or quiet and the ionosphere undisturbed. During an intense auroral display no activity was heard, nor has any correlation been observed with visible meteor showers.

It seems most improbable that the whistlers heard here are propagated along the dipole field passing through Scott Base, as the lines of force in this case would extend to 24 Earth radii above the magnetic equator, and the gyro-frequency would be in the vicinity of 100 c./s.

Distortion of the dipole field by a strong equatorial ring current could possibly allow whistler propagation along lines of force between conjugate points in high geomagnetic latitudes. This hypothesis, however, does not seem tenable when it is considered that periods of maximum whistler activity at Scott Base have so far occurred during quiet magnetic conditions.

There is no record of lightning discharges being observed in high polar latitudes, and it seems improbable that these could occur as there is insufficient thermal radiation from the Sun to produce the necessary air movements. In these regions there appear to be no natural phenomena capable of initiating whistlers.

During the period that whistlers and 'sferics' have been heard an intense and electrically active low-pressure area has existed some 3,000 km. north of Scott Base. Many of the noises heard could undoubtedly have originated in this area. It is probable that the whistlers heard at Scott Base are propagated from lower latitude regions, first along the appropriate magnetic flux line, and then by reflexion from the lower ionosphere.

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Visibility of Noise on Television Pictures

In investigations of the visibility of random noise in television pictures[1,2], it has been found that for narrow-band noise which is just visible the required noise power increases by about 20 db. as the centre frequency is raised from 0·15 to 2 Mc./s. For frequencies between 2 and 3 Mc./s., the noise power remains nearly constant[1], or shows a small fall[2]. It has been suggested[1] that this may be because of the generation of intermodulation products of low-frequency noise, due to the non-linearity of the voltage/brightness characteristic of the television tube. These low-frequency products should be much easier to see than the original high-frequency noise. It follows that the non-linearity should also affect visibility of noise if a sinusoidal signal, together with noise, is applied to the tube control-grid. In this case, sum and difference frequencies of the signal and noise should be produced. An experiment which appears to demonstrate the expected intermodulation effect has been carried out.

A normal television raster was displayed on the tube of a television monitor, the monitor being adjusted so that zero-level signal at the video amplifier input, that is, 0·7-V. double-amplitude peak, produced a brightness excursion between subjective black and peak white. A sinusoidal signal and random noise were then applied at the video amplifier input. The root-mean-square level of the noise, set at −40 db., was obtained by subtraction of 17 db. from oscilloscope measurement of the quasi peak-to-peak level[1] relative to 0·7-V. double-amplitude peak. This noise-level was quite low, but fairly representative for television. The noise band had a sharp top-cut at 3 Mc./s., and extended down to about 50 c./s. The noise was either 'white' (uniform power distribution over the frequency band) or 'quasi-triangular' (power per unit band-width increasing with frequency). The following results were practically independent of tube brightness setting. The visibility of 'white' noise appeared to be unaffected by presence of the sinusoidal signal, although the signal was increased to zero-level, and the frequency varied between 0·1 and 3 Mc./s. However, application of a sinusoidal signal of small amplitude drastically increased the visibility of 'quasi-triangular' noise. Visibility of noise increased with signal-level and, for a fixed level, maximum visibility occurred at a particular signal frequency f_s. This frequency was between 2·5 and 2·9 Mc./s., and increased as the noise spectrum was increasingly peaked at the higher frequencies. As the signal frequency was shifted towards f_s, from either above or below, the noise became progressively coarser in appearance. This was presumably because the approach of f_s to the mean 'carrier' frequency of the noise tended to give the noise envelope as the difference intermodulation product. For the 'quasi-triangular' noise spectrum of Fig. 1, an appreciable increase in visibility of noise was produced by application of a −40 db. signal, f_s being 2·9 Mc./s.

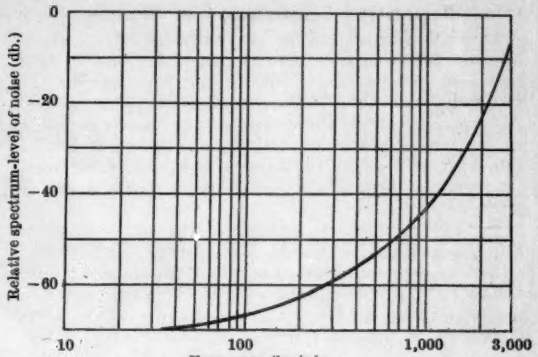

Fig. 1

Further details of this experiment, and others concerned with the effect of non-linearity on noise in television, will be published elsewhere. I wish to thank the Director of Engineering of the British Broadcasting Corporation for permission to publish this communication, and the head of the Designs Department under whose direction the work was carried out.

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Repetitive Stimulation of Muscle

During a study of the effects of repetitive stimulation on the intracellular electrical activity of frog sartorius muscle fibres, alterations were noticed in the voltages of the second and subsequent spikes. At the same time, there was a progressive decrease in $t_{1/2}$ after-potential following the second and following spikes. All the experiments were performed on the green frog *Hyla coerulea* at a temperature of 22° C.

In preliminary experiments, the frequency of stimulation was increased from 10/sec. to 330/sec., which was the maximum frequency the muscle would follow on indirect stimulation. Up to a frequency of approximately 140/sec., spike voltage and duration remained of normal dimensions, and the $t_{1/2}$ after-potential was not appreciably altered after multiple spikes. Above this frequency, important changes were produced in spike voltages and durations, and $t_{1/2}$ after-potential. Fig. 1 shows the records obtained in a single muscle fibre with a progressively increasing number of stimuli at a frequency of 200/sec. A single muscle spike is followed by a negative after-potential of 13–17 mV., with a $t_{1/2}$ value of 13–18 m.sec. A second impulse 5 m.sec. later causes a reduction in the spike voltage, an increase in spike duration, and a shortening of the after-potential. As the number of spikes is increased, spike voltage decreases further until approximately the sixth spike, when a constant voltage is maintained for following spikes. At the same time, $t_{1/2}$ after-potential decreases until it reaches 6 m.sec., in this record, after the eleventh spike. Generally, once a $t_{1/2}$ of 6 m.sec. had been reached, no more spikes could be elicited. These results were repeated in many fibres, and all showed the same general trend of reduction in spike voltage and $t_{1/2}$ after-potential to limiting values which were constant for each muscle studied. Voltage of the negative after-potential did not appreciably alter as the number of stimuli was increased.

Experimental procedures which altered the $t_{1/2}$ after-potential, such as varying external concentrations of potassium, sodium and calcium ions, decreased or increased the number of spikes necessary to produce a $t_{1/2}$ of 6 m.sec. In all experimental conditions, a $t_{1/2}$ value of 6 m.sec. was reached.

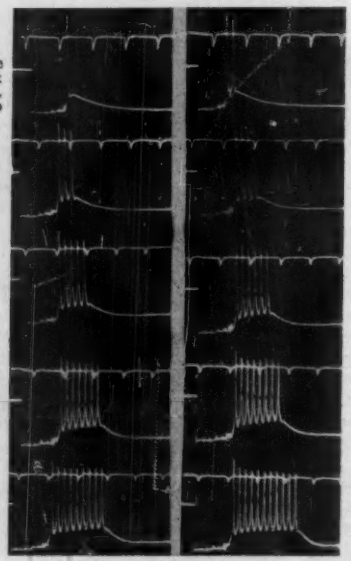

Fig. 1

It is thought that the progressive shortening of the after-potential is due to an accumulation of potassium ions immediately outside the muscle fibres.

Publication of details of this work will follow after these preliminary observations have been more fully studied.

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Electrical Responses of Neuron Cell-Bodies in Sodium-free Media

The electrical activity of frog spinal ganglion cells is maintained, and even enhanced, when the external sodium has been totally replaced by equimolar amounts of either choline or tetraethylammonium[1]. Further investigations suggested that quaternary ammonium ions do not actually substitute for sodium as carriers of the action current, but probably exert a pharmacological action on the membrane or in the perikaryon[2].

A new series of experiments were performed to assess the effects on frog spinal ganglion cells of other related compounds which maintain the excitability of frog nerve fibres[3] or crab muscle fibres[4] deficient in sodium. The various solutions used contained, in addition to the amount of the drug tested, 1·8 m*M* calcium, 2 m*M* potassium, and sucrose to make up isotonicity (*p*H 6·4–7·0).

Sodium-free 112 m*M* solutions of tetramethylammonium, diethanol-dimethylammonium and acetylcholine chlorides had effects similar to those of a 112 m*M* choline chloride solution. A sodium-free 5–10 m*M* solution of tetrabutylammonium chloride maintained the excitability of a number of cells, but higher concentrations irreversibly depolarized and blocked them. A sodium-free 112 m*M* solution of ammonium chloride (*p*H adjusted to 7·0) exerted a powerful depolarizing action on the cells, but overshooting and prolonged electrical responses were obtained with 25 m*M*, although the resting potential still had a low value. A sodium-free 112 m*M* solution of guanidine hydrochloride maintained the excitability of the cells though the latter were slightly depolarized in this medium. A sodium-free 112 m*M* solution of hydrazine (*p*H adjusted to 6·4) had a very characteristic effect on the cell-body, as compared with the other onium ions. The configuration of the action potentials obtained in this medium was practically indistinguishable from that of responses in normal Ringer. Action potentials could be evoked by 'direct' and also by 'indirect' (that is, by propagated nerve impulses) stimulation.

With the exception of hydrazinium ion, the various active onium ions used in sodium-free solutions produced action potentials with a characteristic configuration (namely, peak, plateau, slow falling-phase), different from the 'normal' brief spikes recorded in Ringer's solution. The duration of the electrical responses, more than their peak height or rate of rise, was dependent on the kind and concentration of the drug applied. These prolonged action potentials

might be considered as a particular, 'abnormal' manifestation of electrical activity induced by drugs. However, the striking similarity between 'hydrazinium spikes' and 'sodium spikes' suggests a single mechanism underlying the production of at least both brief responses, and apparently denies the exclusive necessity of external sodium for the generation of a 'normal' type of action potential in spinal ganglion cells. Moreover, it seems reasonable to assume that hydrazinium ion acts in the same way as the other onium ions, and it is not responsible for the actual transport of charge[2]. Electrical activity in the sodium-free media also seems unrelated to sodium entry, although the possibility of a partial retention of this ion in the extracellular spaces cannot be dismissed altogether. Calcium ions do not seem to play a direct part in the generation of electrical activity (Koketsu, K., Cerf, J. A., and Nishi, S., unpublished work). It could be suggested that hydrazinium and other onium ions condition the excitatory reaction and play an indirect part in the generation of electrical activity. The shape of the action potentials produced would depend on the ion species, however, and all intermediates can actually be recognized between the brief 'sodium' or 'hydrazinium spikes' and the prolonged 'tetraethylammonium' and 'tetrabutylammonium potentials'. It can be noted in this connexion that a moderate lengthening of the action potential, with appearance of a slight hump on the falling-phase, was occasionally observed in normal Ringer.

We wish to thank Dr. R. Lorente de Nó, of the Rockefeller Institute for Medical Research, for kindly supplying most of the drugs used in this study, and for his valuable suggestions.

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Anomalous Bactericidal Action of Bromamine

As part of an investigation on the properties of the bromamines, their bactericidal efficiency was examined. These compounds are formed during the chlorination of sea water swimming pools in the presence of ammonia[1] and also in fresh water where bromine and not chlorine is used to sterilize the water.

Houghton[2] has made some studies of the bactericidal effects of solutions prepared by the action of chlorine on solutions containing ammonium salts and bromide ions, and found that these solutions were more efficient in destroying bacteria than were solutions containing only chloramine.

I have shown spectrophotometrically that solutions so prepared contain mainly monochloramine together with some monobromamine[1]. Experiments were accordingly made to determine the bactericidal effect of pure monobromamine relative to pure monochloramine.

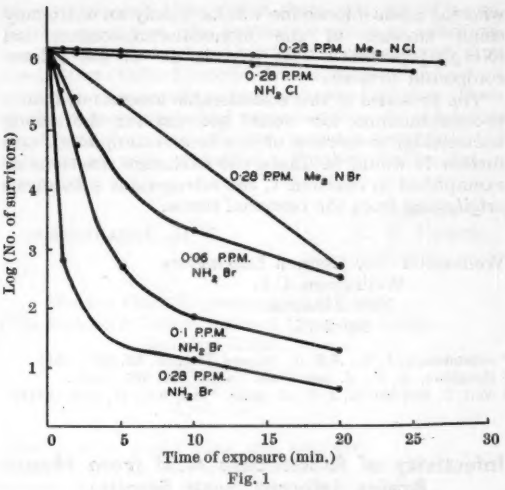

Fig. 1

Solutions of the amines were prepared by adding excess ammonium sulphate to solutions of hypochlorite for mono-chloramine, and to solutions of hypobromite for mono-bromamine. The solutions were buffered to approximately *p*H 8·2 with bicarbonate. 1-litre quantities of these solutions were treated with suspensions of *Escherichia coli* type 1, wild strain (from 18-hr. cultures that had been well washed), to give a cell density in the solutions of approximately 10^7/ml. Aliquots were taken after 1, 2, 5, 10 and 20 min. and pipetted into 0·5 per cent solution of sodium thiosulphate. The numbers of viable bacteria were then estimated by conventional plate counts and the results were plotted as the logarithm of the number of survivors against time.

For monochloramine the plot gave the expected linear relationship, but for monobromamine the curve showed a sharp break between 2 and 5 min., after which the rate became more linear and slower (Fig. 1). Amperometric determination of the halogen remaining after the experiments showed very little loss.

Unpublished work has shown that monobromamine reacts with dimethylamine even in the presence of a substantial excess of ammonium ion, and it was thought likely that a reaction of the type:

$$(\text{Bacterial}) -R_2NH + NH_2Br \rightarrow R_2NBr + NH_3 \quad (1)$$

took place. Accordingly, N-chlorodimethylamine and N-bromodimethylamine were prepared as described, substituting dimethylamine hydrochloride for the ammonium sulphate; and tested for their bactericidal action. For both the chloro- and the bromo-compounds the plot of the logarithm of the survivors against time was linear, the bromo-compound acting more rapidly than the chloro-compound.

The pK_a values of the monobromamine and monochloramine are respectively 6·5 (unpublished work) and 1·0 (ref. 3), and thus at the experimental *p*H value nearly 1 per cent of the bromo-compound is present as the monobromammonium ion (NH_3Br^+), which will have a strong tendency to react as follows:

$$NH_3Br^+ \rightarrow NH_3 + Br^+ \quad (2)$$

whereas monochloramine will have only an extremely small amount of the monochlorammonium ion (NH_3Cl^+) present: one part in 10^7 of the chloro-compound present.

The presence of this considerable amount of monobromammonium ion would account for the strong bactericidal properties of the bromo-compound, and further it would facilitate the exchange reactions as exemplified in reaction 1, the nitrogenous substances originating from the bacterial tissue.

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Infectivity of Ribonucleic Acid from Mouse Brains infected with Semliki Forest Virus

Evidence has been recently presented to show that the ribonucleic acids isolated by phenol extraction from tobacco mosaic virus[1], from ascites tumour cells in mice infected with Mengo encephalitis virus[2] and from mouse brains with Eastern equine encephalitis virus[3] are infectious. In the present communication, the infectivity of the ribonucleic acid isolated from the brains of mice infected with Semliki Forest virus is reported. This virus can also multiply in mosquitoes[4] but causes no known human disease.

Three-day-old Swiss mice were inoculated intracerebrally with 0·02 ml. of a 10^{-4} dilution of a homogenate of mouse brain infected with Semliki Forest virus. One day after infection, the brains were harvested, frozen in 'dry-ice'–ethanol and homogenized with 0·14 *M* sodium chloride–0·01 *M* sodium phosphate, *p*H 7·0, to give a 10 per cent homogenate. The supernatant is here designated as 'virus preparation'.

The ribonucleic acid was prepared by phenol extraction and precipitated twice with 65 per cent ethanol and once with 1 *M* sodium chloride following the procedures of Wecker and Schäfer[3]. The final precipitate was resuspended in phosphate buffer to a volume equal to that of the original mouse brain before dilution.

Infectivity titres, expressed as *LD*50, were determined by the intracerebral injection of serial 10-fold dilutions in mice, 0·02 ml. for one-day-old mice and 0·03 ml. for 30- to 40-day-old mice. The 10 per cent brain homogenate and the ribonucleic acid preparation were regarded as 10^{-1} and 10^{0} dilutions respectively in calculating these titres.

The ribonucleic acid preparation exhibited about 0·1 per cent of the infectivity of the infected brain homogenate from which it was prepared (Table 1). The homogenate of the brains, harvested after infection with 10^{-3} dilution of the ribonucleic acid preparation, fixed complement with anti-Semliki Forest virus serum, an indication that the virus had multiplied in the recipient mice. Thus, the ribonucleic acid preparation contains all genetic information necessary for the production of complete Semliki Forest virus.

The ultra-violet absorption spectrum of the ribonucleic acid preparation was characteristic of nucleic acid, with a maximum at 257 mμ and a minimum at 230 mμ. The ratio between the optical densities was 2·1. Protein could not be detected by the biuret reaction. However, these results do not exclude the possibility that the infectivity might be due to small amounts of contaminating virus particles.

Table 1. Comparisons of Semliki Forest Virus and Ribonucleic Acid Preparations

		Log *LD*50	
		Virus preparation	Ribonucleic acid preparation
A	No treatment	6·9	3·8
B	Control	5·5	3·7
	After ribonuclease 50 μgm./ml. 25° C.; 10 min.	5·6	*
	After deoxyribonuclease 50 μgm./ml. 25° C.; 10 min.		3·3
C	Control	3·6	1·9
	After centrifugation (top supernatant)	1·6; 1·6	1·3
D	Control	6·0	3·5
	After sodium deoxycholate 0·1 per cent; 4° C.; 1 hr.	4·0	3·7
E	Control	4·1	2·3
	After sodium deoxycholate 0·1 per cent; 4° C.; 1 hr.	2·0	2·2

* No mice died at 10^{1} dilution

In attributing the observed infectivity to the ribonucleic acid itself, rather than to contamination with intact virus, previous authors have relied on the differential effects of centrifugation and nuclease digestion on crude preparations of virus and ribonucleic acid[2,3] (cf. Table 1, *B* and *C*). In the present investigation, precautions were taken to make the two reaction systems reasonably comparable before repeating the differentiating procedures. The Semliki Forest virus was diluted ten-fold and centrifuged at 40,000*g* for 1 hr. at 3° C. to remove extraneous tissue material, and the supernatant was diluted with the ribonucleic acid preparation to give an infectivity only one to two hundred times that of the ribonucleic acid system. The concentration of free ribonucleic acid was equal in the two systems.

As shown in Table 1, *B* and *C*, even under these conditions ribonuclease treatment did not reduce the infectivity of the virus preparation, presumably because the ribonucleic acid of the intact virus is protected by its protein coat. Furthermore, centrifugation sufficient to remove 99 per cent of the original infectivity of the Semliki Forest virus preparation reduced the infectivity of the purified ribonucleic acid by only 50 per cent.

In an effort to provide further evidence, the two preparations were exposed to the action of sodium deoxycholate, which has been shown to inactivate many of the arthropod-borne viruses[5]. 99 per cent of Semliki Forest virus was inactivated, but the infectivity of the ribonucleic acid preparation was not affected (Table 1, *D* and *E*).

These results, although not decisive, add to the now impressive body of evidence that the infective entity in ribonucleic acid preparations is ribonucleic acid itself and not a contaminating virus particle.

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Protective Effect of Trace Elements other than Selenium against Dietary Necrotic Liver Degeneration

RATS fed on diets containing certain yeasts as their sole source of protein develop a dietary necrotic liver degeneration, leading to early and rapid death. Necrogenic diets are deficient in three factors, vitamin E [1], cystine [2] and a 'Factor 3' [3], each of which will alone prevent the manifestations of disease. Potent Factor 3 concentrates have been prepared from casein hydrolysates[4] and, recently, Schwarz and Foltz[5] have shown that similar concentrates prepared from kidney powder hydrolysates contain selenium in bound form. Addition of sodium selenite to rat diets (to supply 4 μgm. of selenium per 100 gm. of diet) gave complete protection against death from liver necrosis during the experimental period of thirty days, indicating that selenium might be part of Factor 3. Schwarz and Foltz have inferred that "selenium is an essential trace element".

We were prompted to investigate the addition of certain other trace elements to necrogenic diets, particularly those which, it was considered, might take part in oxidation-reduction mechanisms. Table 1 shows the results obtained by the addition of a number of trace elements at levels below their toxic levels (where these are known)[6]. Lead (alone) and a group of four metals, cerium, mercury, titanium and vanadium (together), were inactive. Molybdenum, osmium and cobalt (together) delayed the deaths by necrosis beyond 130 days in three rats out of seven. In the same test, the protective effect of selenium, cystine and α-tocopherol has been demonstrated. In a second test (Table 2), molybdenum, osmium and cobalt were given separately as well as in combination. Each of the three metals had some activity at the levels employed, but not all the animals receiving the supplement were protected. Further studies are in progress.

Table 1. EFFECT OF ADDITIONS TO THE NECROGENIC DIET*

Supplement	p.p.m.	No. of rats †		Remarks
		Total	Alive at 88 days	
Nil		6	0	
Sodium selenite	0·05	7	7	7 alive at 200 days
L-Cystine (0·6 per cent)		7	7	6 " " " "
DL-α-Tocopherol acetate (100 mgm./kgm.)		8	8	7 " " " "
Lead acetate	0·5	10	1	Survivor died at 89 days
Ammonium molybdate	0·5	7	3	Survivors died at 130, 154 and 170 days
Osmium tetroxide	1·0			
Cobalt sulphate	1·0			
Ceric sulphate	1·0			
Mercuric chloride	1·0	8	1	Killed. Liver normal
Titanous chloride	1·0			
Ammonium meta-vanadate	5·0			

* Basal diet (per cent): dried bakers' yeast, 30; vitamin E-free lard, 5; sucrose, 55; salts, 5; B vitamins in glucose, 5; vitamins A, D and K orally. The salt mixture contained the following trace elements: iodine, fluorine, copper, manganese and aluminium.

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Heparin and Christmas Factor

HEPARIN has been shown to combine with Chargaff's[1] lung thromboplastin, which contains phospholipid. It inhibits the formation of intrinsic plasma thromboplastin[2], and Douglas[3] has shown that it must inhibit blood coagulation at an early stage. Heparin is also known[4] to combine specifically with the β-lipoproteins of plasma or serum and to depress the plasma β-lipoprotein concentration when injected *in vivo*. Christmas factor has been shown to be present in a crude α- and β-globulin fraction of plasma[5] and it may contain phospholipid[5].

A normal thromboplastin generation test was carried out using normal absorbed plasma, serum and platelets but with the prior addition of a suitable concentration (0·85 unit/ml.) of heparin. Little thromboplastin was formed. If the addition of heparin to the normal mixture is delayed until 3 min. after recalcification when the formation of thromboplastin is already maximal, the addition of heparin does not then affect the result; that is, maximal thromboplastin activity persists. Thus it is probable that heparin at this concentration prevents the formation of thromboplastin, but does not prevent its action once it is formed, and does not exhibit

Table 2. EFFECTS OF MOLYBDENUM, OSMIUM AND COBALT

Supplement	Element (p.p.m.)	No. of rats	No. dying	Mean age at death (days)	Range (days)	Survivors at 100 days	Remarks*
Nil		10	9	60	42–92	1	Livers grossly necrotic
Ammonium molybdate	0·5	9	5	50	35–67	4	Post-necrotic scarring in two livers†
Osmium tetroxide	1·0	10	6	58	40–86	4	Livers normal
Cobalt sulphate	1·0	10	6	55	40–78	4	Post-necrotic scarring in one liver
Ammonium molybdate Osmium tetroxide Cobalt sulphate	0·5 1·0 1·0	9	5	55	37–84	4	Post-necrotic scarring in two livers

* Survivors killed and examined at 100 days.
† In all livers the scarring was confined to the left lobes and was accompanied by enlargement of the right central lobe.

any antithrombic activity in the sub-sample tubes.

Attempts to correct the defect produced by the addition of this critical amount of heparin showed that the addition of excess serum normalized the system. The addition of serum absorbed on alumina, which is deficient in Christmas factor and Factor VII, or the addition of serum from two cases of Christmas disease which is presumably deficient only in Christmas factor, both failed to do so. The addition of toluidine blue and protamine sulphate, both of which prevent the antithrombic activity of heparin, also failed to correct the defect.

A volunteer was given 2,500 units of heparin intravenously. 30 min. later blood was taken and it was found to have a long clotting time, but when mixed with normal plasma it did not prolong the clotting time of the normal plasma. Thus there was probably no free heparin in the volunteer's plasma at this time. In the thromboplastin generation test the volunteer's serum was shown to be abnormal, and this abnormality was corrected by the addition of normal serum diluted 1:10, but not by sera from two cases of Christmas disease similarly diluted. In these tests the volunteer's blood was therefore indistinguishable from that of a case of Christmas disease. It is concluded that heparin, *in vitro* and *in vivo*, may in some way interfere with the formation or the action of serum Christmas factor.

The apparently specific effect of heparin on Christmas factor was compatible with this factor being a lipoprotein. The lipoproteins of normal serum were separated by mixing serum with 20 per cent glycerin and centrifuging for 13 hr. at 170,000*g* in a preparative ultracentrifuge. The supernatant β-lipoprotein was removed and samples of this and the remainder were dialysed free of glycerol and tested in the thromboplastin generation test. The β-lipoprotein was inactive, while the remainder contained the full activity of the original serum. Thus Christmas factor is not in the β-lipoprotein fraction as isolated by this method.

It is concluded that the inhibition of the early stages of blood coagulation *in vitro* by heparin might be due to the action of heparin on Christmas factor. Since the intima of blood vessels may be lined by mucoitin, an acidic muco-polysaccharide like heparin, and since Christmas factor is involved at an early stage in blood coagulation, these tentative conclusions may be related to the inception of thrombosis *in vivo*. Further investigations are in progress.

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Isolation of an Erythropoietic Fraction from the Plasma of Rabbits made severely Anæmic with Phenylhydrazine

The plasma of rabbits made severely anæmic with phenylhydrazine, with less than 3·7 gm. hæmoglobin per 100 ml. of blood, contains erythropoietic material. The erythropoietic activity has been demonstrated in heterologous species, for example, rats[1], mice[2] and dogs[3], in the filtrate obtained after boiling the anæmic rabbit plasma at *p*H 5·5 for a few minutes.

The following procedure has yielded a fraction which, on a protein basis, is 5–10 times more potent than the filtrate of the boiled anæmic plasma. The plasma proteins were precipitated at 5° C. at *p*H 6·0 by the addition of four volumes of saturated ammonium sulphate. The precipitate was extracted with 50 per cent saturated ammonium sulphate, and the soluble fraction was dialysed free of sulphate. Sodium chloride was added to the dialysand to 0·9 per cent, the *p*H of the solution was adjusted to 5·5, after which it was heated at 95–100° C. for 5 min., cooled quickly and filtered. The filtrate was concentrated by lyophilization to one-tenth its volume, dialysed until negative for chloride. The dialysand was concentrated further to a protein concentration of 2 per cent. Seven volumes of saturated ammonium sulphate solution were added to three volumes of the protein solution. The *p*H was brought to 6·0. After standing overnight at 5° C. the solution was filtered. The filtrate was dialysed free of sulphate and dried by lyophilization. 300 mgm. was obtained from 2·8 l. of anæmic plasma.

0·18 mgm. injected subcutaneously into mice daily for three days increased the reticulocytes from 2·1 to 10·2 per cent. 0·75 mgm. injected daily for three days into starved rats increased the uptake of injected iron-59 in the circulating blood to 22·6 per cent. 2·16 mgm. injected daily for two weeks into normal adult rats increased their hæmoglobin from 13·2 to 16·2 gm. per 100 ml. of blood.

When 750 μgm. of the dried material was submitted to electrophoresis on a strip of paper 30 mm. wide (veronal buffer, 0·05 *M*, *p*H 8·6) nearly all the protein material appeared as a broad band, which moved a little slower than serum albumin and faster than α_1-globulin, with a faint trace in the α_2-globulin region.

The dried material was submitted to moving boundary electrophoresis by the method of Mitchell and Herzenberg[4]. Two-thirds of the protein and all the demonstrable erythropoietic activity were in one band. Two faster-moving and one slower-moving bands had no demonstrable activity, and gave no augmented activity when added to the one active band.

On the basis of these and other experiments the following properties may be assigned to the erythropoietic principle. Erythropoietic activity so far has been inseparable from protein. Digestion with chymotrypsin or trypsin destroyed the activity. The active material is not dialysable, it is not lost after dialysis with 6 *M* urea, and it may be dried by lyophilization. It is stable to boiling at *p*H 5·5 for short periods. It is precipitated in the presence of all the plasma proteins by 80 per cent saturation with ammonium sulphate; the purified material in 0·6 per cent solution is soluble in 70 per cent saturated ammo-

nium sulphate. Erythropoietic activity as measured by reticulocytosis in mice, increased uptake of iron-59 in rats and polycythæmia in rats went together in one electrophoretic fraction. Neither dialysis nor electrophoresis has separated a prosthetic group necessary for its activity. The active fraction gave a positive test for sialic acid[5] (mucoprotein).

Work is in progress on purification of the electrophoretic fraction.

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Cytolipin *H*, a Pure Lipid Hapten isolated from Human Carcinoma

ANTISERA prepared by injecting rabbits with cytoplasmic fractions or homogenates of human tissues frequently contain antibodies directed against substances extractable from the tissue with organic solvents and presumably lipid in nature. Material derived from tumours is reported to be more effective than that from normal tissues in eliciting this type of antibody[1], suggesting that tumours may contain larger quantities of one or several lipoprotein antigens or possibly antigens qualitatively different. Exploration of this problem by the methods of immunochemical analysis is obstructed by several complications: the antigenic complexity of lipid extracts, the multiplicity of antibodies in the antiserum reagents, and the paucity of information regarding non-specific lipid–protein interactions for many classes of lipids. A fourth complication is of even greater moment than the other three combined, namely, the fact that specific lipid–protein interactions are markedly influenced by certain ubiquitous, non-specific lipids[2].

Analytical measurements can therefore shed only dim light on the problem of antigenic specificity and distribution until methods are developed which take into account the complex nature of the observed interactions. The development of such methods has, in turn, been hampered by lack of knowledge concerning the structure of lipid molecules which combine specifically with antibody as well as the absence of an adequate number of models for study. This communication reports the isolation from human carcinoma of a pure lipid hapten, its partial chemical characterization and its immunochemical properties. This substance, for which we propose the name 'cytolipin *H*', is a four-residue molecule the structure of which is capable of exact determination. It therefore offers a promising point of departure in attacking the complex problems associated with immunochemical studies of lipids.

The method of isolation was as follows: human epidermoid carcinoma (H.Ep. No. 3) grown in cortisonized rats was homogenized in a Waring blendor with 20 ml./gm. chloroform/methanol (2 : 1). The extract was washed with water according to Folch *et al.*[3], giving 2·5 gm. of a crude lipid soluble in chloroform per 100 gm. of wet tissue. The crude lipid was fractionated on silicic acid at 5° C. in 6 gm. lots using a discontinuous-gradient elution method with hexane and ethanol[4,5]. Fractions eluted with hexane and 5 per cent ethanol in hexane were rejected; the fractions emerging with 17 per cent ethanol in hexane were collected, yielding 30–90 mgm. per run, phosphorus 2–3 per cent, hexose (aminodiphenyl method[6]) 6–12 per cent. Material from ten runs was pooled to give 630 mgm., phosphorus 2·1 per cent, hexose 6·9 per cent. This was dissolved in 5 ml. of ethyl ether and 10 ml. of ethanol at 60°. A small quantity of insoluble material was rejected. On chilling, 171 mgm. was deposited, hexose 18·5 per cent. An additional 90 mgm. was obtained by adding 15 ml. of ethanol and 4 ml. of water, hexose 19·9 per cent. The supernatant, containing 376 mgm., phosphorus 2·49 per cent, hexose 2·7 per cent, was discarded. The fractionation was repeated to remove an additional 57 mgm. of soluble material, phosphorus 2·0 per cent, hexose 3·2 per cent, and the remaining phospholipid was removed by chromatography over 'Florisil' in chloroform/methanol (2 : 1)[7]. The yield was 80·9 mgm. of colourless material, phosphorus less than 0·02 per cent, hexose 36·5 per cent, nitrogen 1·47 per cent, which was recrystallized three times from hot pyridine/acetone (1 : 6) to give 63·8 mgm. having $[\alpha]_D^{24°} = -10·8°$ (concentration 2 per cent in pyridine). Recrystallization from methanol/chloroform (9 : 1) did not affect the rotation.

This substance, cytolipin *H*, is insoluble in water and contains no ester groups or phosphorus. It is ninhydrin-negative, but on acid hydrolysis (3 *N* hydrochloric acid, 100°, 2 hr.), ninhydrin-positive material is released that is associated exclusively with a long-chain base (sphingosine). Hydrolysis also releases two molecules of hexose that migrate on paper (ethyl acetate/pyridine/water[8]) with the R_F values of glucose and galactose and appear in equal concentration. Evidence at hand suggests that cytolipin *H* is a cerebronyl–sphingosyl–glucosido–galactoside, but much additional structural work remains to be done. The composition is consistent with the formula $C_{54}H_{103}O_{14}N$ (molecular weight, 990·4); calculated: C, 65·49; H, 10·48; N, 1·41; hexose, 36·4 per cent; iodine No. 26; found: C, 65·46; H, 10·31; N, 1·38; hexose, 36·7 per cent; iodine No. 32.

Cytolipin *H* activity was followed by complement-fixation with rabbit anti-human reticulum cell sarcoma serum. The pure substance reacts very poorly in this test, but when combined with the optimal quantity of auxiliary lipid (a mixture of equal parts of lecithin and cholesterol), less than 0·001 μgm. can be readily determined. Under these conditions, cytolipin *H* reacts with rabbit antisera prepared by injecting many different types of human tumours. Isofixation curves[9] of cytolipin *H* with two rabbit anti-human tumour sera are shown in Fig. 1.

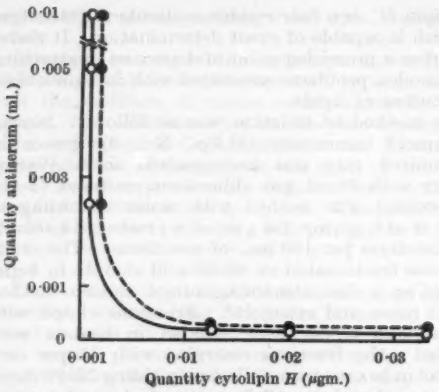

Fig. 1. Isofixation curves determined with cytolipin *H* and antisera to cervix carcinoma (broken line) and reticulum cell sarcoma (solid line). Three 50 per cent haemolytic units (0·00375 ml. of guinea pig serum); 2 hr. incubation at 20° C. (ref. 9)

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Effect of Certain Polyphenylated Aliphatic Hydrocarbons on the Phagocytic Activity of the Reticulo-Endothelial System

In a recent communication to *Nature*, Nicol *et al.*[1] reported the effect of various stilbene compounds on the phagocytic activity of the reticulo-endothelial system, intimating that stimulation was associated with certain aspects in the chemical structure, and that the strongest stimulants possessed high œstrogenicity. The present communication reports the effect on reticulo-endothelial phagocytic activity of some polyphenylated aliphatic hydrocarbons related to the synthetic œstrogens of the diphenylmethane series.

The present experiments were carried out on 50 male white mice (*T.O.* Swiss strain) of 20–30 gm. body-weight. Five of the animals were used for assessing the effect of each compound on the phagocytic activity of the reticulo-endothelial system, each animal receiving one subcutaneous injection of 0·5 mgm. of each substance in 0·05 ml. of arachis oil daily for six days. The phagocytic activity of the reticulo-endothelial system was measured on the eighth day, as described in the previous communication[1].

Twenty-five animals were used as controls. Each received one subcutaneous injection of 0·05 ml. arachis oil daily for six days and then showed an average phagocytic index or *K* value of 13 ± 2·4.

Table 1. Effect of Certain Polyphenylated Aliphatic Hydrocarbons, containing at least one *para*-Hydroxyl Group, on the Phagocytic Activity of the Reticulo-Endothelial System

	Compound used	Phagocytic index (*K* value)	Œstrogenic activity (R.U.) (mgm.)
A	3 : 3-Di-(*p*-Hydroxyphenyl)-*n*-pentane	16 ± 2·2	5
B	3-(*p*-Hydroxyphenyl)-3-phenyl-*n*-pentane	11 ± 1·1	10
C	*p*-Hydroxyphenyldiphenylmethane	13 ± 1·7	25
D	1-(*p*-Hydroxyphenyl-1 : 1-diphenylpropane)	10 ± 0·6	100 (inactive)
E	*p*-Hydroxyphenyltriphenylmethane	8 ± 1·6	100 (inactive)
	Control values for 25 animals	13 ± 2·4	

Table 1 shows the relative *K* values of five polyphenylated aliphatic hydrocarbons investigated, together with their known levels of œstrogenicity. The results indicate that compound *E* has a profound depressant effect on phagocytosis only hitherto found following the administration of cortisone[2] in which the phagocytic index was reduced to $K = 7$. Compound *E* is the only non-steroid found by us to cause such marked depression of phagocytic activity. Compounds *B* and *D* show only a minor depressant action; compound *C* causes no alteration; while compound *A*, which is œstrogenic in the rat following doses of 5 mgm., has a slight stimulatory effect.

We are indebted to Prof. D. H. Hey for help in the interpretation of the above results and to Sir Charles Dodds for generously supplying these compounds. We also gratefully acknowledge assistance from the Central Research Fund of the University of London and from the Medical Research Council.

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Species Difference in Pyridine Nucleotide Synthesis by Erythrocytes

Leder and Handler[1] have described the synthesis of pyridine nucleotide from nicotinamide and glucose by human erythrocyte homolysates in amounts as much as ten times the normal content and they identified the synthesized material as nicotinamide mononucleotide. These authors also suggested that fructose diphosphate and adenosine triphosphate

Table 1

Species	No. of observations	γ-Pyridine nucleotide (as diphosphopyridine nucleotide per c.c.): whole blood	erythrocytes	Synthesis of pyridine nucleotide by erythrocytes from nicotinamide + glucose (γ-pyridine nucleotide formed/c.c. red blood cells)	γ Ribose/c.c. of whole blood	γ Ribose synthesized/c.c. red blood cells/hr.
Man	8	30·6	62·5	314·7	—	—
Monkey	6	63·1	145·0	nil	—	—
Rat	6	94·2	205·0	nil	186·0	82·3
Mouse	2	194·1	407·5	nil	—	—
Guinea pig	6	37·8	77·1	346·9	147·2	75·3
Rabbit	2	59·5	131·8	nil	—	—
Sheep	3	—	192·1	nil	—	—

were required for optimal synthesis of nicotinamide mononucleotide. While synthesis of pyridine nucleotide is thus known to occur *in vitro* by washed human erythrocytes, its presence and its synthesis in other mammalian species have not yet been examined.

In our recent studies on the metabolism of pyridine nucleotide it was observed that the washed red blood cells of the rat were unable to synthesize that substance under conditions similar to those employed by Leder and Handler[2] in human erythrocyte studies. This finding induced us to examine further the behaviour of different species of animals, namely, mouse, rat, guinea pig, rabbit, sheep, monkey and man, as regards synthesis of pyridine nucleotide by erythrocytes.

The total pyridine nucleotide content of the whole blood was estimated by the method of Levitas *et al.*[3]. The capacity of fresh erythrocytes, washed four times at 3° C. with four volumes of glucose–Ringer phosphate, *p*H 7·2, to synthesize nicotinamide mononucleotide was estimated by the method of Leder and Handler[2]. In some experiments with rats and mice, the incubation mixture contained fructose-1:6-diphosphate, adenosine triphosphate and D-ribose, in addition to nicotinamide and glucose.

The results presented in Table 1 demonstrate that, of the seven species studied, only man and guinea pig erythrocytes were capable of synthesizing pyridine nucleotide under the conditions of the experiment. However, all the species that were unable to synthesize it had a higher pyridine nucleotide content of blood than guinea pig or man. This suggests that the major site for synthesis of nicotinamide mononucleotide in these species may be a tissue other than blood.

Although it is uncertain whether the formation of nicotinamide mononucleotide in blood cells occurs by the direct phosphorylation of nicotinamide riboside by adenosine triphosphate as shown in liver preparations by Rowen and Kornberg[4], or by the reaction between the base and ribose-5-phosphate or 5-phosphoribosyl-1-pyrophosphate[5], it is reasonable to assume that the conversion of glucose-6-phosphate to ribose phosphate by way of a hexose monophosphate shunt may be an essential step in the synthesis of nicotinamide mononucleotide from nicotinamide and glucose. My results demonstrate that the formation of ribose phosphate from glucose-6-phosphate in rat and guinea pig erythrocytes, as well as the ribose content of the whole blood of these two species, were almost equal. It was evident, therefore, that the ribose phosphate did not seem to be a limiting factor in synthesis of pyridine nucleotide in rat erythrocytes. It is hoped that experiments with erythrocyte homolysates and liver preparations now in progress may provide some information regarding the comparative role of these tissues in synthesis of pyridine nucleotide in different species of animals.

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Investigations into Temperature Changes on the Surface of Human Tooth Enamel

IN one of the first observations made with the aid of the microscope, Leeuwenhoek[1,2] found that he could detect fewer organisms in scrapings taken from teeth after drinking hot fluids than in scrapings taken before the drink. Although many investigations have been made into the physical effect of thermal changes upon enamel and into the effects of conducted heat upon the dental pulp, there is no evidence in the literature of Leeuwenhoek's observation having been pursued.

In the present series of experiments, investigations are being carried out from the aspect of the effects of temperature changes upon chemical or bacterial activity taking place upon the surfaces of human teeth. To ascertain the range of such changes on enamel surfaces during meals, pilot experiments were performed using copper-constantan thermocouples attached to the surface of enamel and in areas between teeth. Meals were eaten at a serving temperature of 60–70° C., during which thermocouple readings were taken every 30 sec.

It was found that maximum temperatures of 50–60° C. were reached and temperatures of 40–45° C. were maintained for up to ten minutes at a time. In areas between the teeth, the temperature on the enamel surface took, on average, thirty minutes after the finish of the meal to return to 37° C.

When measuring surface temperatures it is necessary to know the thermal conductivity of the material the surface of which is under examination, and since only a rough estimate of the thermal conductivity of enamel has been made[3] it was thought that as a preliminary investigation the thermal conductivity of enamel should be determined. The apparatus in use for this is a modification of that used by Phillips, Johnson and Phillips[4] for the determination of the thermal conductivity of dentine and dental cements. Results indicate that the value of the thermal conductivity of enamel is of the order 0·002 C.G.S. units, and that variations occur with the age of the

enamel. Since the value is in the same range as ceramic materials, thermistors will be more suitable for use on enamel surfaces than thermocouples. Experiments are being conducted with thermistors recording on to pen-recorders.

It would seem that if the detailed investigations confirm the indications of the pilot work, it may be incorrect to perform *in vitro* experiments into dental caries at 37° C. and regard them as being a reproduction of *in vivo* conditions.

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Effect of the Nitrogen and Sulphur Content of Organic Matter on the Production of Ammonium and Sulphate

At this Laboratory, investigations into the decomposition of soil organic matter have been concerned with the effect of sulphur and nitrogen content on decay. To simplify the problem in its preliminary stages, and to gain better control of variables, the decomposition of mixtures of pure organic substances was studied.

This communication reports the effect of varying the nitrogen and sulphur content of such 'organic matter' on production of ammonium and of sulphate.

Mixtures of sucrose, casein, glycine and cysteine were used to vary the nitrogen and sulphur content of the organic matter—the carbon content was kept constant. Solutions of mixtures of these compounds, together with an inorganic salt solution, were inoculated with a soil extract and 40 ml. was then added to 300 gm. of clean sand in a series of 500-ml. flasks. After placing a small tube of sodium hydroxide solution in the flasks, they were closed with a thin sheet of polyethylene and were incubated at 27° C. With the quantities of organic matter used, diffusion of oxygen through the polyethylene into the bottle was rapid enough to sustain respiration at a rapid and probably maximal rate. Absorption of the carbon dioxide by the sodium hydroxide was much more rapid than diffusion out through the polyethylene. (Negligible loss of carbon dioxide occurred even when it was evolved very rapidly by action of acid on carbonate.) On the other hand, the concentration of carbon dioxide in air is so low that diffusion into the bottle was very small and in any event could easily be measured by a blank determination. At each sampling two bottles per treatment were taken to determine the sulphate, ammonium and carbon dioxide produced (no nitrate was detected). This allowed calculation of the carbon, nitrogen, and sulphur remaining in the organic form—though this calculation is subject to error if losses occur by formation of volatile compounds. It was thus possible to follow changes in the ratios of organic carbon to organic nitrogen and of organic carbon to organic sulphur (carbon/nitrogen and carbon/sulphur ratios).

Formation of ammonium was sometimes considerably delayed. This only happened when the initial carbon/nitrogen ratio was wider than about 5/1 and was only well marked when there was at least one part of sulphur to every hundred parts of carbon. One such curve is shown in Fig. 1, treatment 1. Calculations showed that the upward trend in such curves never occurred until respiration had lowered the carbon/nitrogen ratio to about 5/1.

However, when the proportion of sulphur in the organic matter was reduced, ammonium was formed more rapidly and before the carbon/nitrogen ratio had fallen to 5/1. Fig. 1 shows release of ammonium from organic matter with an initial carbon/nitrogen ratio of 13·3/1 and initial carbon/sulphur ratios varying from 100/1 to 400/1. Release of ammonium from material of wide carbon/sulphur ratio occurred much more rapidly and at much wider carbon/nitrogen ratios—as wide as 12/1 for treatments 4 and 5. It would seem that utilization of nitrogen was limited by the supply of sulphur and that nitrogen in excess of microbial needs was mineralized.

The highly significant initial rise and subsequent fall in the curve for treatment 4 in Fig. 1 is worthy of note. On this treatment the micro-organisms apparently did not attack the organic compounds at the same rate: it would seem that the nitrogen-rich compound (in this case glycine) was attacked more rapidly than the energy-rich compound (sucrose) and excess nitrogen was mineralized. Later, presumably when the sucrose was fully utilized, some of this nitrogen was immobilized. A similar 'premature' formation of sulphate occurred in some other experiments, but in most cases the micro-organisms appeared to attack the simple organic compounds at the same rate.

Graphs of sulphate production against time—like those for ammonium production—sometimes showed a flat initial phase before production of sulphate occurred. The upward trend in the curves did not

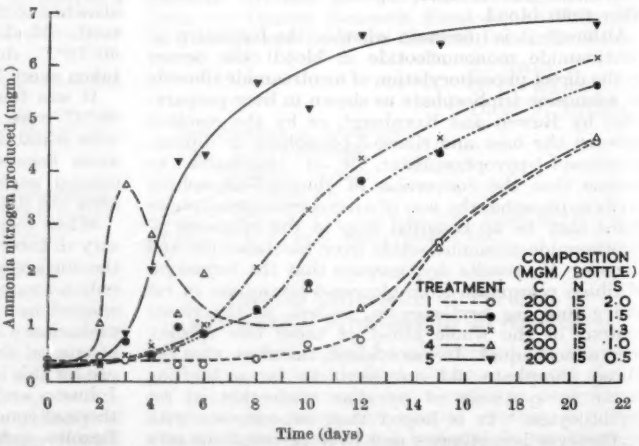

Fig. 1. Release of ammonium from mixtures of sucrose, glycine, and cysteine of the composition shown. The maximum value of the least range for significance (ref. 1) at $P < 0{\cdot}01$ is 1·45 mgm. ammonia nitrogen

occur until respiration had lowered the carbon/sulphur ratio to about 50/1. When the proportion of nitrogen in the organic matter was reduced, production of sulphate tended to be more rapid—though the effect did not seem to be nearly as well marked as the effect of reducing the proportion of sulphur on production of ammonium.

These results suggest that mineralization of an element from organic matter depends not only on the proportion of that element in the organic matter but also on the proportion of the other elements. It is probable that a similar generalization applies to immobilization of elements, and in fact other results from these experiments have shown that immobilization of phosphorus was reduced when the proportion of nitrogen or of sulphur in the organic matter was reduced.

The statistical analysis was performed by Mr. P. F. May, of the Division of Mathematical Statistics, Commonwealth Scientific and Industrial Research Organization. It is intended to publish this work in greater detail elsewhere.

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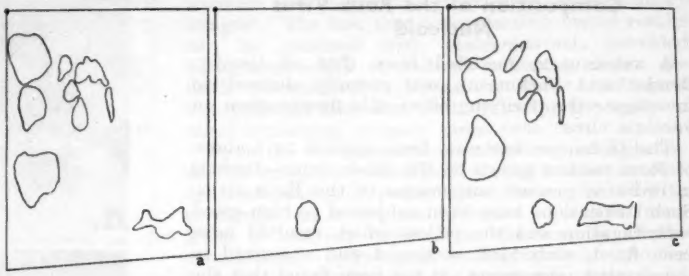

Fig. 1. Tracings of descending chromatograms developed with ninhydrin. In each case the solution was applied to the upper left-hand corner. The horizontal dimension represents movement in the butanol/acetic acid/water solvent, and the vertical the movement in phenol. (*a*) Factor I solution, 0·025 ml.; (*b*) γ-aminobutyric acid solution, 0·01 ml. of 1 mgm./ml.; (*c*) Factor I solution, 0·025 ml.; γ-aminobutyric acid solution, 0·01 ml.

Absence of γ-Aminobutyric Acid from Brain Extracts containing Factor I

Florey[1] and Florey and McLennan[2,3] have described some of the actions of extracts of brain and spinal cord which possess an inhibitory activity on certain synaptic processes, both in mammals and in invertebrate animals. For example, these extracts, which are said to contain 'Factor I', can block transmission in sympathetic ganglia, can inhibit monosynaptic reflexes, can block neuromuscular transmission and the neurogenic heartbeat of Crustacea, and can inhibit the discharge of crustacean stretch receptor neurones. Bazemore, Elliott and Florey[4] have reported that an active component of extracts containing Factor I is γ-aminobutyric acid. Since that time it has been shown that γ-aminobutyric acid does have effects of an inhibitory nature, especially in Crustacea[5] and when applied to the mammalian cerebral cortex[6]. However, a comparison of the actions of Factor I and γ-aminobutyric acid on those structures where the former is active has shown that, except in Crustacea, the effects obtained with the two are not comparable, and it was concluded that they are not identical[7].

In the present experiments a solution of Factor I was applied to Whatman No. 4 filter paper, and subjected to chromatographic separation for free amino-acids. The solvents used were *n*-butanol/glacial acetic acid/water (4 : 1 : 5, v/v/v) in one dimension, and 80 per cent (w/w) aqueous phenol in the second. The chromatograms were developed with ninhydrin solution to reveal the amino-acid spots.

Fig. 1*a* shows the distribution of spots obtained with a solution of Factor I prepared according to Florey and McLennan[3]. Fig. 1*b* shows the spot obtained when a solution of pure γ-aminobutyric acid was applied to the paper, and Fig. 1*c* the result when Factor I with added γ-aminobutyric acid was applied. It is evident from these chromatograms, which were all performed simultaneously, that there is no spot in Fig. 1*a* corresponding to γ-aminobutyric acid, such as appears clearly in Fig. 1*c*, where the substance was added artificially to the solution of Factor I.

It can be concluded from this experiment that extracts containing Factor I prepared by the method of Florey and McLennan, which possess the whole complex of actions described by those authors, contain no γ-aminobutyric acid, which cannot therefore be the active component of Factor I. Nor can it be argued that the quantity of Factor I applied to the paper in Fig. 1*a* contains an undetectably small amount of γ-aminobutyric acid, for the amount applied is 2½–5 times that required to block the crayfish stretch receptor neurone, and is therefore at least 2½ times more than the amount applied in Fig. 1*b*[7]. A possible explanation for the finding of Bazemore *et al.*[4] that γ-aminobutyric acid was present in the extracts containing Factor I is that it was split off from some larger molecule in the course of the relatively drastic extraction procedures which were used. It may perhaps be conjectured that this postulated larger molecule, of which γ-aminobutyric acid is a fragment, is the true active ingredient of Factor I solutions.

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Composition of the Rous Virus Nucleoid

A TECHNIQUE, modified from that of Gessler, Bender and Parkinson[1], was recently devised to investigate the purifying effect of a fluorocarbon on vaccinia virus[2].

The technique has now been applied to nodules of Rous tumour grown on the chick chorio-allantois in order to prepare suspensions of the Rous virus. Such suspensions have been subjected to high-speed centrifugation and the pellets which resulted have been fixed, embedded, sectioned and examined in the electron microscope. It has been found that the only recognizable formed structures present in the pellets were uniform spherical particles about 75 mμ in diameter (Fig. 1), and biological tests integrated with the morphological work have established that these particles were in fact the Rous virus[3]. Fragments of the pellets containing the virus are ideal both for examination by electron and fluorescence microscopy after enzyme digestion, and for cytochemical study.

The nucleoid of the Rous virus is known to lie in a central zone separated from the viroplasm by a fine membrane[4]. In order to investigate the nature of the nucleoid, samples of the pellets containing the virus have been treated with ribonuclease. The samples were first fixed with potassium permanganate[5] which, unlike the more commonly used osmium–sucrose fixative for electron microscopy[6], allows subsequent digestion by both deoxyribonuclease[7] and, under certain conditions, ribonuclease. After fixation, the samples were placed in iced 30 per cent alcohol and allowed to warm to room temperature[5]; they were then incubated for 2 hr. at 37° C. in 30 per cent alcohol containing 0·1 per cent by weight of ribonuclease, protease-free, and recrystallized three times (Worthington Biochemical Corporation, Freehold, New Jersey). Control samples were incubated simultaneously in 30 per cent alcohol without the enzyme. After incubation, all the samples were dehydrated, embedded in *n*-butyl methacrylate and sectioned for examination in the electron microscope.

The incubation procedure made the particles appear ragged and extracted (Fig. 2). It is nevertheless clear that in the control preparations, which were not exposed to the ribonuclease, the nucleoid and outer limiting membrane remained intact (Fig. 2*a*). On the other hand, the nucleoids were removed from particles which had been subjected to ribonuclease digestion (Fig. 2*b*); such particles also appeared slightly swollen as if some central supporting structure had been removed. The specificity of the ribonuclease digestions in conjunction with the findings of the control experiments demonstrate that the nucleoid of the Rous virus contains a substantial amount of ribonucleic acid. This work will be reported in detail elsewhere[8] together with a discussion of its significance.

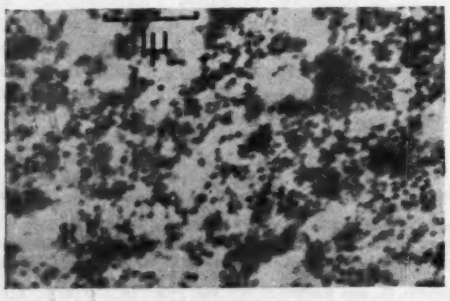

Fig. 1. Electron micrograph of a section through a pellet prepared from a suspension of the Rous virus which had been treated sever times with a fluorocarbon. Uniform virus particles about 70–75 mμ in diameter are almost the only formed structures present. Permanganate fixation. × 14,000

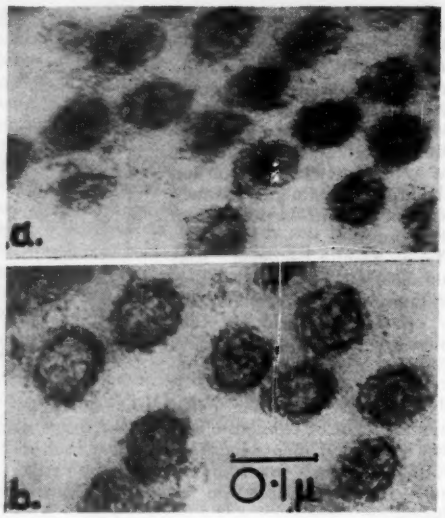

Fig. 2. Electron micrographs of thin sections of Rous virus particles. (*a*) Control particles which had been incubated in 30 per cent alcohol at 37° C. for 2 hr.; the nucleoid and outer limiting membrane can be distinguished. (*b*) Particles which had been incubated in the same way as the controls except that the 30 per cent alcohol contained 0·1 per cent by weight of ribonuclease; the nucleoids have been removed and the particles appear slightly swollen. Permanganate fixation. × 130,000

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A Cobalt-Accumulator Plant, *Clethra barbinervis* Sieb. et Zucc.

DURING an investigation to determine if variations in the heavy-metal content of vegetation and soil could be used in prospecting for chromite ore bodies in the Hinokami district, Tottori Prefecture, a tree, *Clethra barbinervis* Sieb. et Zucc., was unexpectedly found to be an accumulator of cobalt.

Leaves of seventeen different kinds of trees collected from 199 locations in the neighbourhood of the mine were analysed for iron, nickel, cobalt, copper, zinc, manganese and chromium. The cobalt and nickel

Table 1. Cobalt, Nickel and Iron Content of Plant Leaves

Species	No. of samples	Average content (p.p.m. of ash) Co	Ni	Fe	Average ratios Ni/Co	Fe/Co
Clethra barbinervis Sieb. et Zucc.	17	661	140	548	0·38	1·37
Quercus crispula Blume	69	2·6	42·2	614	20·7	386
Deutzia crenata Sieb. et Zucc.	26	5·3	24·0	791	7·8	175
Castanea crenata Sieb. et Zucc.	24	3·6	31·8	846	11·1	243
Cynoxylon japonica Nakai	24	2·0	24·6	688	20·3	482
Lindera umbellata Thunberg	11	4·3	26·7	696	7·1	204
Other species	28	3·9	32·2	671	12·8	289

content of the ash of a variety of trees other than *Clethra* sp. ranged from less than 1·0 to 22·5 p.p.m. and from 3·2 to 120 p.p.m., respectively. More than one hundred times as much cobalt and several times as much nickel were found in *Clethra* sp. as in other plant species. Normally, plants contained from seven to twenty times more nickel than cobalt, but *Clethra* sp. contained more cobalt than nickel, although it was not richer in iron.

The total nickel content of the soil (*B*-horizon), which was mostly derived from serpentine parent material, ranged from less than 100 to 3,010 p.p.m. dry weight, the average being 1,005 p.p.m.; the total cobalt content also ranged from 10 to 9,250 p.p.m., the average being 652 p.p.m. The soil on which *Clethra* sp. was growing did not show any anomalous levels in these elements, yielding on average 1,125 p.p.m. of nickel and 511 p.p.m. of cobalt.

There is no evidence that cobalt is essential for higher plants, although certain species of lower plants and bacteria require this element. The large accumulation of cobalt in leaves of *Clethra* sp. suggests that this element may have some function in higher plants. Further work is proceeding and will be reported in detail elsewhere.

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Morphology of Yeast Mitochondria

There has recently been some controversy as to the possibility of demonstrating other than granular mitochondria of yeast cells[1–3]. It is well known that for a long time the only mitochondria that cytologists were able to demonstrate in yeast cells were round, granular structures. As their minute dimensions make it practically impossible to observe the same cell before and after treatment with fixatives, stains, etc., the identification of yeast mitochondria must necessarily be doubtful. However, knowledge of the structure of the living cell, and the comparison of cytochemical results with the state of the living untreated cell, should be good safeguards against incorrect interpretation. One frequently abstains from using phase-contrast when examining yeast cells because, under the usual conditions of examination, cells of the yeast type which have a high solid content and refractive index give unsatisfactory images[4]. The fact that incomparably better results can be obtained with phase-contrast, provided immersion media of suitable refractive index are used, was stressed in Britain by Barer *et al.*[5], and this principle has been used by us for the study of micro-organisms, notably yeast cells.

From the cytochemical investigations of Ephrussi and his school[6], who used both normal and respiration-deficient strains of yeast, it can be concluded with certainty that in the case of yeasts a positive Janus green *B* reaction depends on the activity of the cytochrome *c* – cytochrome oxidase system. So far as is known, therefore, those structures of the yeast cell which, after careful treatment, can be stained with Janus green may be considered as mitochondria.

When Yotsuyanagi[1], using a double differential staining method, observed thread-like as well as granular structures in yeast cells and identified them as mitochondria, Williams *et al.*[2] denied the presence of long cylindrical mitochondrial threads in yeasts and emphasized that thread-like structures in such cells were only seen as artefacts after they had been stained with 2,3,5-triphenyltetrazolium.

The controversy between Williams *et al.*[2] and Ephrussi *et al.*[3] is solely based on what I believe to be Williams's incorrect interpretation of Yotsuyanagi's results. I should like to correct the statement of Williams *et al.* that "no other observer has ever reported long cylindrical cytoplasmic structures in *Saccharomyces*".

Quite independently of Yotsuyanagi's work, I have in recent years investigated the morphology and continuity of yeast mitochondria. According to my results, thread-like mitochondria seen in yeast cells are true structures of the living cell and not artefacts produced by the use of stains[7]. Using phase-contrast refractometry[8], I succeeded in demonstrating thread-like mitochondria in a number of yeast strains. This method so greatly facilitates their analysis that I was able some years ago to study their living structure by time-lapse microcinematography. One of my film-strips, which shows thread-like mitochondria during budding (*Sacch. carlsbergensis*) and cell-division (*Saccharomycodes ludwigii*) was shown at the meeting of the Research Film Section of the International Scientific Film Association in Göttingen in 1956. Fig. 1 shows the typical shape of thread-like mitochondria with negative phase-contrast. The interpretation of Williams *et al.* that such thread-like structures in yeast cells must be regarded as artefacts is thus refuted by the demonstration of thread-like mitochondria in living, untreated cells.

Provided special care is used, it is possible to stain these thread-like mitochondria with Janus green *B*.

(*a*) (*b*) (*c*)

Fig. 1. *Saccharomycodes ludwigii*: long, thread-like mitochondria in living, unstained cells (*a* and *b*) and during cell-division (*c*). Negative phase-contrast, magnification, × 1,200; refractive index of the medium, 1·377

I could not, however—in contrast to Yotsuyanagi[1]—demonstrate them after fixation. My experience showed that thread-like yeast mitochondria are extremely sensitive to any type of interference with the cell, including vital staining and fixation. Great importance must therefore be attached to the analysis of their living structure. Fragments of thread-like mitochondria, as found, for example, after treating the cells with vital stains, may for a limited period remain stainable with Janus green. Their structure does not, however, correspond completely with what is found in the living cell.

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Fluoroacetamide as a Systemic Insecticide

It has previously been reported that sodium fluoroacetate is a very effective systemic insecticide against *Aphis fabae* Scop.[1,2]. Unfortunately, its use cannot be recommended since it is a very dangerous poison, being both highly toxic and rapid in action.

As a result of the above report, related compounds have been investigated, and it has now been stated that fluoroacetamide is an active insecticide[3], although no details of biological tests have been published. Fluoroacetamide is claimed to be considerably less hazardous to handle than sodium fluoroacetate because it is less toxic and acts more slowly[4,5]. Furthermore, in rats acetamide acts as an antidote to fluoroacetamide but not to sodium fluoroacetate[5,6].

The biological tests were carried out as previously described[5,7]. The test insects were the bean aphis, *A. fabae* Scop., on broad beans, the cabbage aphis, *Brevicoryne brassicae* L., the peach potato aphis, *Myzus persicae* Sulz., on young cabbage plants and the eggs and larvæ of the large white butterfly, *Pieris brassicae* L., also on young cabbage plants.

In tests in which leaves bearing *A. fabae* and *B. brassicae* were dipped, fluoroacetamide was as effective as sodium fluoroacetate, 0·001 per cent solutions containing a wetting agent giving 100 per cent kill. Both were superior to schradan. When leaves bearing eggs of *P. brassicae* were similarly dipped in 0·1 per cent fluoroacetamide solution, 85 per cent of eggs failed to hatch and 70–80 per cent of the larvæ were killed. The same concentration of sodium fluoroacetate had no effect on the number of eggs hatching but killed 98 per cent of the newly emerged larvæ. Less than 10 per cent of the fourth instar larvæ were killed following immersion for 0·5 min. at 20° C. in the 0·1 per cent fluoroacetamide solution plus wetting agent.

When poured on to the soil, for systemic action against *A. fabae*, fluoroacetamide was as immediately effective and as persistent as sodium fluoroacetate: 2 mgm. (in 20 ml. solution) applied to 400 gm. of moist compost giving 100 per cent kill. It was therefore superior to schradan. When applied in the same way against *B. brassicae* and *M. persicae*, fluoroacetamide was superior to sodium fluoroacetate. The former aphid was killed by a dose of 0·2 mgm. and the latter by 1·0 mgm. of fluoroacetamide on the same weight of compost. Applied in this way, neither compound prevented the eggs of *P. brassicae* on the leaves of young cabbage plants from hatching, but all the young larvæ were killed by a dose of 10 mgm. fluoroacetamide or 20 mgm. of sodium fluoroacetate on the soil.

When administered to broad bean plants by the cut tap-root technique[8], the approximate *LD*100 in mgm. per kgm. of fresh plant tissue for *A. fabae* was fluoroacetamide 0·09–0·9, sodium fluoroacetate 0·7, schradan 50. When taken up through the petioles of the leaves of small cabbage plants 5 mgm. of the fluorine compounds or 50 mgm. schradan per kgm. of fresh plant tissue killed all *B. brassicae*. The growth of *P. brassicae* larvæ was prevented by 20 mgm./kgm. of either fluorine compound. For schradan more than 2,900 mgm./kgm. was required.

When applied to the older leaves against all three species of aphids feeding on the younger leaves of their host plants, fluoroacetamide was as effective as or slightly superior to sodium fluoroacetate as a systemic insecticide and in varying degrees superior to schradan.

It is clear that fluoroacetamide is as effective as the more dangerous sodium fluoroacetate as a systemic insecticide. Whether or not it would be safe for use on food crops remains to be proved. A more detailed report will be published elsewhere.

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It may be of interest to report that we found, as preliminary to many field experiments on the systemic insecticidal activity of fluoroacetamide against aphid pests of a number of flowering plants, that cuttings of rose bushes (unidentified species), infested very seriously with *Macrosiphum rosae* L. and their cut ends dipped in solutions of the insecticide at certain concentration (with 0·05 per cent wetting agent added), gave the kills indicated (Table 1).

Table 1

Dilution	Aphid kill	Phytotoxicity
1 in 1,000	100 per cent in 8 hr.	Some signs
1 in 10,000	100 per cent in 8–10 hr.	Nil
1 in 20,000	100 per cent in 24 hr.	Nil
1 in 100,000	Some kill in 24 hr. (young insects) Complete kill in 72–96 hr.	Nil

The above work was done in the late spring of 1953, and arose from the pioneer work of David and Gardiner[1] on the systemic insecticidal activity of sodium fluoroacetate; later work showed that the insecticide was persistent in the rose bushes for a period of about 2–3 weeks, applied as spray or via root only, at a strength of 1 part in 10,000; that is, aphids occasionally began to reappear after this period of time, necessitating a second spray.

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Systemic Insecticides and the Ratio of Green to Dried Hops

IN England when hops are picked by hand the work is assessed in terms of the volume of green hops measured as bushels. The green hops are later kiln-dried to about 9 per cent water content before being pressed into bales and sold by weight. Some growers keep a record of the average number of bushels of green hops required each year to give 1 cwt. of dried hops; this average is called the bushel/cwt. ratio. The ratio may vary from year to year on the same farm and from farm to farm in the same year. This variation has been discussed by Glasscock[1], who suggested meteorological conditions at harvesting as one of a number of possible factors concerned.

During recent years it has been reported that the ratio was increasing beyond the limits of normal variability[2]. Data from five East Kent farms (including Wye College) were examined; in three farms the data related to 1942–57 inclusive, and in the other two they related to 1944–57 and 1949–57 respectively. These data are summarized in Table 1, which also gives values for rainfall during August–September of the appropriate years, recorded at Wye College.

Table 1 shows that: (*a*) The average bushel/cwt. ratio for all farms increased from 91 for 1942–49 to 104 for 1950–57; (*b*) the average rainfall during August–September increased from 3·87 to 6·52 in. for the same two eight-year periods. Both these increases are statistically significant at $P = 0{\cdot}01$. The possibility at once suggests itself that the increase in rainfall may have been responsible for the observed increase in the ratio, but this hypothesis is not confirmed by statistical examination of the data. No correlation exists between rainfall and the bushel/cwt. ratio within either of the two periods 1942–49 or 1950–57.

Systemic organo-phosphorus insecticides for control of aphis and red spider were first used commercially on hops in 1949. They have proved most effective and their use has since become general. Of the five farms examined, three introduced systemic insecticides in 1950, one in 1951 and Wye College in 1953; all five farms have since continued to use them. Data for individual farms show that in the years when systemic insecticides were first used the bushel/cwt. ratio rose at once to a level well above the existing average; in three farms it rose to levels greater than previously recorded. It is of significance to note that at Wye College the ratio remained low in the very wet years of 1951 and 1952; when systemic insecticides were introduced in 1953 the ratio rose at once to the high levels at which it has since remained.

Table 1. DATA ON THE RATIO OF BUSHELS OF GREEN HOPS HARVESTED PER CWT. OF DRIED HOPS FOR FIVE FARMS IN EAST KENT, AND ON AUGUST–SEPTEMBER RAINFALL AT WYE, KENT, FOR THE YEARS 1942–57 INCLUSIVE

Year	Bushel/cwt. ratio values for five farms in East Kent					Average ratio for all farms	August–September rainfall (in.)
	Wye College	Farm "E"	Farm "H"	Farm "M"	Farm "W"		
1942	—	109	77	92	—	93	4·53
1943	—	103	88	94	—	95	2·67
1944	—	96	88	86	91	90	4·48
1945	—	98	88	93	100	95	2·83
1946	—	89	87	90	85	88	7·01
1947	—	89	89	91	88	89	0·90
1948	—	99	83	88	85	89	4·47
1949	100	99	86	84	89	92	4·08
Average 1942–49						91	3·87
1950	100	110*	89*	93	94*	97	4·59
1951	114	112	96	97*	99	104	8·93
1952	103	115	97	97	99	102	8·17
1953	120*	115	92	95	93	103	6·33
1954	127	111	87	96	93	103	5·83
1955	115	110	98	100	107	106	4·71
1956	127	120	88	97	108	108	5·95
1957	125	125	87	105	107	110	7·68
Average 1950–57						104	6·52

* Year in which systemic insecticides were first used.

It appears probable that the introduction of systemic insecticides has played an appreciable part in increasing the bushel/cwt. ratio. The causes of this increase have not been investigated. A possible explanation is that the superior control of aphis and red spider given by these systemic compounds results in the crop being picked in a more succulent condition than when contact insecticides only were used. It is also possible that the presence of these compounds in the plant may have had physiological side-effects resulting in this increase in the ratio.

This work will be discussed in more detail in the Annual Report of the Department of Hop Research for 1957 which is to be published shortly.

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A New Species of *Atolla*

WHILE making a study of the scyphomedusan *Atolla* in north Atlantic waters I recently found that there were two species, *A. wyvillei* and *A. vanhöffeni*[1]. I can now state that there is a third species. Like *A. vanhöffeni*, this is a small species, apparently not exceeding 30 mm. in diameter, but the shape of the base of its stomach is similar to that of *A. wyvillei*.

Whereas *A. vanhöffeni* and *A. wyvillei* have typically 20 and 22 marginal tentacles respectively, this new

species has usually 20 or 24 tentacles. It differs also from *A. wyvillei* in that the septa separating the rhopalar and tentacular gastral canals tend to be nearly straight and of uniform thickness, and are almost completely covered to their centripetal ends by the thin part of the coronal muscle. In *A. wyvillei* the septa tend to be club-shaped in appearance, diverging at their ends and extending centripetally beyond the margin of the thin part of the coronal muscle. Its range of coloration appears to be similar to that of *A. wyvillei*.

In view of its small size, I propose to name this species *Atolla parva* n.sp. A fuller description will be given in a later publication, but in the meantime it is hoped that those engaged in studying plankton collections may be able to add to our knowledge of the distribution of the species.

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Grain in the Glume of Wheat

In the wheats, as in most grasses, there are empty glumes at the base of each side of the spikelets, and the florets consist of a lemma (flowering glume), palea and flower. In *Triticum vulgare* Host, ten or eleven flower primordia are formed in most spikelets[1] and although in some varieties under good conditions many spikelets carry four or five grains, in most varieties grain is produced only in the two or three basal florets, and the higher florets are undeveloped. The only recorded regular departure from this system is the basal sterility found in some speltoid mutants of *T. vulgare*[2]. In these the lemma of the first floret of most spikelets is empty, and in one mutant both the basal florets are sterile: the initiation of the flower primordia is partially or completely suppressed[3]. One of the more rare abnormalities of flower development in normal varieties is the occurrence of rudimentary florets in the axils of the glumes[3].

Regular development of flower parts in the axil of the second glume has been found in a compactoid wheat. The development varies from the production of a rudimentary palea within the glume to the formation of a complete flower which may set a grain; no increased growth of lodicules[3] has been observed. The 42 ears from five plants grown in the Crop Research Division glasshouse have been examined, and of the 648 well-developed spikelets three, from one plant, were 'normal', 608 showed the abnormality within one glume and 37 showed it in both glumes. Where the order of the florets was noted it was found that the second glume had flower parts in the axil, and where both sides were affected the development in the second glume was the more advanced. Of 222 grains produced by the five plants, 44 were formed in the glumes. In all ears there was incomplete development of the terminal spikelets.

The density of the ears was similar to those of awnless compactoids previously described[4,5], and the appearance of two of the spikelets is shown in Fig. 1. In Fig. 2 the parts of one spikelet are arranged in order. The glumes are long (up to 13 mm.), keeled

(*a*) (*b*) (*c*) (*d*)

Fig. 1. Spikelets of wheat: (*a*) *T. vulgare* var. Aotea; four grains. (*b*) Compactoid; on left, glume normal, no grain in first flower; grains on right in second flower and in glume. (*c*) Reverse of spikelet from same ear as (*b*); on left, glume with palea, no grain in second flower; grain on right in first flower. (*d*) *T. compactum*, *S*2767; four grains

(*a*) (*b*) (*c*) (*d*) (*e*) (*b*) (*c*) (*a*)

Fig. 2. Spikelet of compactoid, parts in order: (*a*) Glume; (*b*) unfertilized flower; (*c*) lemma; (*d*) grain in second normal floret; (*e*) central florets

and fragile, and the shoulder is very narrow; the lemmas and the glumes are awned.

The compactoid line is descended from the cross[6] of two awned varieties from the Crop Research Division wheat collection, *S*357 from Crete and *S*1556 from India. The awned progeny of a sub-compactoid F_2 plant consisted of 27 compactoids, 43 sub-compactoids and 32 normal plants, and an F_3 of 42 plants grown from three compactoid F_4's was all compactoid. Chromosomes were counted in root tips of nine of these, including the five discussed above, and all had 44 chromosomes; the material is presumably a stable tetrasome IX compactoid[5].

In the F_2 the abnormality was shown in compactoids, and in the compact part of a sub-compactoid ear, but not in a normal ear. It is thus closely related to compactoidy, and appears, like compactoidy[4], to be independent of the *compactum* factor. It is not found in *T. compactum* Host, and in ears from the F_1 with *T. compactum* (*S*2767) as male parent only the upper spikelets had flower parts in the glumes. It is possible that all compactoids show the character, though some (Mac Key[4], Fig. 53; Sears[5], Fig. 10) do not appear to have fertile glumes. The glumes of another tetrasome compactoid[7] were, apart from being awnless, similar to those of the present material, but their fertility could not be assessed from the photograph (their Fig. 22). A duplication compactoid found recently in unrelated material had relatively short glumes, and no awns; in the one ear harvested most of the 16 spikelets contained two grains, 11 of them had flower parts in the second glume, and in the top third of the head five grains were produced in glumes. It is suspected that the abnormality had not been recorded previously because the effect is not conspicuous unless a grain is formed, and if a grain is formed the impression is given that the glume has been broken off. Both the outer bracts are structurally glumes, and not lemmas.

The production of flower parts in the compactoid glume is an extension of the cytological and pheno-

typic reciprocality between speltoids, particularly 'sterile base', and compactoids. Awnedness may be of significance[6]; the present material is fully awned, and basal sterility is expressed more fully in awnless speltoids[3], but it is doubtful whether much importance should be attached to simply-inherited characters. Compactoids provide evidence of the genetical characteristics of chromosome IX, part of the *B* genome of wheat, the origin of which is unknown[8], but the normal disomic effects of chromosome IX cannot be predicted, and not until an *Aegilops*, or perhaps an *Agropyron*, with a fertile glume is discovered should any evolutionary significance be attached to this character. (*Added in proof:* Okamoto (*Wheat Inf. Service*, **6**, 3; 1957) (E. R. Sears, personal communication) has shown that chromosome IX is in the *A* genome, and has thus reduced the historical importance of speltoidy and compactoidy.)

I wish to thank Mr. E. J. Beuzenberg for the chromosome counts, and Mr. C. J. Miles for the photographs.

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Bat Erosion as a Factor in Cave Formation

Observations in three bat-infested caves in Trinidad suggest that roosting bats can play a considerable part in cave excavation where the rock is soft. The best example of this bat erosion is to be seen in a cave in soft coral reef limestone in Mt. Tamana. Wherever the roof is dry, as indicated by the absence of stalactite growth, it is pitted with numerous bell-shaped cavities, the upper parts of which are lined, by day, by a layer of closely packed sleeping bats. On the cave floor below each such cavity is a conical mound of bat guano.

Measurement of these cavities with a pair of long wooden calipers showed depths ranging from 3 ft. to 6 ft. and diameters at the mouth from $1\frac{1}{2}$ ft. to $2\frac{1}{2}$ ft. In the deeper ones measured, the terminal dome and upper part of the shaft were of much the same dimensions as a complete smaller cavity, while the lower part of the shaft widened farther. However, the majority were of irregular shape, having merged with neighbouring cavities.

The bell shape, consisting of a tapered shaft surmounted by a dome, accords with the view that the cavities have been excavated by the claws of generations of roosting bats. Certain species tend to sleep clinging to an overhanging surface and crowded close together, and they can be observed to jostle each other, trying to secure a central position. Such jostling could, over a long period, be expected to erode a cavity in soft granular rock. As the cavity deepened, bats would tend to alight at the lip and climb up the shaft to reach the dome. Thus the lowest and oldest part of the shaft would have been subjected for the longest time to erosion by climbing bats, and could be expected to be of greater diameter than the upper part.

At least nine species of bat have been recorded from these caves, and both total and relative numbers have been observed to vary. Their roosting habits would make an interesting study, but the remoteness of the caves renders such an undertaking difficult.

W. A. King-Webster
J. S. Kenny

Fisheries Department,
Port-of-Spain,
Trinidad, B.W.I. Sept. 26.

The Cromer Forest Bed: Preglacial or Interglacial?

The relation of the Cromer Forest Bed Series to the overlying glacial deposits and to the earlier Crag Series has long been a problem, but the recent communication in *Nature* by Prof. P. G. H. Boswell[1] should do much to dispel the idea that the Cromerian stage can be described as an 'Interglacial'. No glacial tills or similar deposits have ever been seen below this Series, and therefore from the point of view of stratigraphy its description as 'Interglacial' can only cause confusion. The very few glacial erratics which have been found in and below the Crag can be attributed to the action of sea-ice, and cannot be counted as representing a 'glaciation'; these erratics are so rare that in practice unfossiliferous Crag deposits can be distinguished in the field from most glacial beds by the fact that erratics are scarcely ever found in the Crag.

As regards conditions during the formation of the Cromer Forest Bed itself, Clement Reid[2] believed that the fossil plants and non-marine shells are in general similar to those now living in Norfolk, with a few exceptions such as *Corbicula fluminalis*. More recently, Woldstedt[3] described a pollen analysis of samples taken from part of the Forest Bed Series as showing a phase with early birch and pine forests succeeded later by a mixed oak association. If work now being done at Cambridge confirms Woldstedt's conclusions, this will suggest that a major climatic fluctuation took place during the formation of the Cromer Forest Bed of a type seen in some interglacial episodes, though differing in detail. This apparent contradiction of a climatic fluctuation which is not preceded by a glacial deposit makes an examination of the marine fauna of the underlying Weybourne Crag most important, in order to find out whether this fauna represents arctic conditions.

In the absence of glacial erratics or actual glacial deposits, it has in fact been argued by Zeuner[4] that the marine fauna of the Weybourne Crag, which underlies the Forest Bed Series, contains sufficient cold indicators to prove glacial conditions before the formation of the Cromer Forest Bed. He considered that an analysis of the marine fauna proves that the cold increased unevenly during Crag times, and that at least two cold episodes represent pre-Cromerian glacial phases; one of his cold episodes is stated to have occurred during the formation of the Weybourne Crag. But Clement Reid[2] showed that only a few cold indicators are known in the Weybourne Crag, and that only one of these (*Astarte borealis*) is at all common, the rest being very rare indeed; in any event a Mediterranean shell is also known to occur (*Astarte incrassata*). Among the marine

formations of eastern England it is not the Weybourne Crag which shows the coldest conditions, but the Bridlington Crag of Yorkshire, which is believed to be later than the Cromer Forest Bed[5]. It seems to me that we can conclude that Zeuner's analysis suggests that there may have been fluctuations of climate during Crag times, and these may even go back into the Pliocene, but there is insufficient faunal evidence for calling these fluctuations 'glacials' or 'interglacials'. For similar reasons it is difficult to agree with Woldstedt's use[3] of the term 'Cromer Forest Bed Interglacial'.

As Sainty has pointed out[6], Clement Reid came to the conclusion after several years of work on the Cromer coast that among the occasional marine shells found in the estuarine parts of the Cromer Forest Bed Series, no new 'arrivals' have been recognized as compared with the Weybourne Crag fauna; and in fact the marine fauna of the Weybourne Crag itself only differs from that of the earlier Norwich Crag in the 'arrival' of one new species (*Tellina balthica*) as compared with the Norwich Crag; this species is a common living British shell to-day, and (in spite of its name) is not typical of specially cold conditions. As no new 'arrivals' of cold indicators have yet been found in the Weybourne Crag, there is no proof from the marine fauna that this deposit represents any colder conditions than the Norwich Crag. In view of the lack of geological evidence for truly glacial conditions in the later Crag beds which were formed before the Cromer Forest Bed Series, it seems to me unwise to refer to the Cromer Forest Bed as an 'Interglacial', at least until we know more about conditions during the formation of the Norwich and Weybourne Crags.

D. F. W. Baden-Powell

University Museum,
Oxford.
May 24.

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"Physics and Metaphysics"

Nature of March 8 contained, over the signature of Prof. L. Rosenfeld, a very lively criticism of the book "Causality and Chance in Modern Physics", published last year by Prof. David Bohm, a book for which I have written the preface. I do not think that the criticisms of Prof. Rosenfeld are justified.

The current probabilistic interpretation of the quantum theory leads in its general lines to exact conclusions. But since it denies every possibility of a precise image of the development of phenomena in space and time, it continues to be surrounded by a certain obscurity. It is not at all certain that it furnishes a complete description of physical reality: scientists as eminent as Planck, Einstein and Schrödinger have always expressed doubts on this subject. The idea of Prof. Bohm that it may be necessary to introduce new 'levels' of physical reality deeper and more hidden than those revealed by current experience therefore seems perfectly defensible to me. For my part, returning after a number of years to certain ideas that I had considered previously when I was developing the first bases of wave mechanics, I have examined this question in the light of the conceptions of Prof. Bohm and in collaboration with certain young scientists at the Institut Henri Poincaré. In particular, I have asked myself whether it would not be possible to find an interpretation which, while retaining all the results given by probabilistic quantum physics, would permit us to obtain a more clear and more intelligible image of microphysical facts. The problem is certainly not an easy one, but I do not believe it to be so impossible as Prof. Rosenfeld thinks; and a certain number of results already obtained in this direction seem encouraging to me.

In any event, no theoretical interpretation can ever be established with a final and complete definitiveness, and for this reason alone it is always permissible to submit those that have already been accepted to a new examination. At the end of the previous century, the great majority of physicists belonged to the 'energeticist' school, which wanted to develop thermodynamics and its related subjects on purely formal bases, and which rejected, often with great disdain, all atomic and corpuscular representations. However, the interpretation of thermodynamics in terms of statistical mechanics, while taking complete account of the success of classical thermodynamics, has permitted us to go very much further. The existence of 'microphysical levels' of atoms and molecules, which the statistical mechanical interpretation of thermodynamics introduces, has been completely and clearly demonstrated. It is not forbidden to think that something analogous could happen again in the years to come. The introduction of a 'sub-quantum' milieu, deeper than the level of current microphysics, could permit the interpretation of the calculations of the present quantum theory in a clearer way, and might lead us further than the current theory can go.

In addition, the quantum theory in its accepted form seems, in a certain measure, to have exhausted its powers of prevision. After a number of years, becoming more and more formal, it has begun to have as many failures as it has successes. Even its proponents themselves seem now to admit the need to make some efforts to modify its bases. In these conditions, it does not seem to me justified to condemn *a priori* the efforts of those who try to take in a new point of view, and to obtain an image of the physical world more intelligible than that based on the conception of complementarity which remains, in spite of everything, rather obscure.

Louis de Broglie

Academie des Sciences,
Paris 1e.

The impossibility of eliminating the relations of complementarity from atomic physics is not a question of opinion but a simple logical point, as devoid of obscurity, as, for example, the impossibility of defining absolute simultaneity. For a detailed discussion of the points raised in M. de Broglie's comments I may refer the reader to my contribution to the book "Louis de Broglie, Physicien et Penseur" (Paris, 1952), a revised version of which appeared in *Science Progress*, **41**, 393 (1953).

L. Rosenfeld

University of Manchester,

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, June 30

UNIVERSITY COLLEGE (in the Anatomy Theatre, Gower Street, London, W.C.1), at 5 p.m.—Dr. J. D. Robertson: "The Molecular Biology of Cell Membranes".*

Wednesday, July 2

MEDICAL RESEARCH COUNCIL (at the National Institute for Medical Research, Mill Hill, London, N.W.7), at 5 p.m.—Prof. Samuel Graff (U.S.A.): "Experiments with Continuous Metazoan Cell Cultures".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURERS, Grade II (honours graduates or associate members of a professional institution), IN MATHEMATICS at Singapore Polytechnic—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (July 3).

SENIOR LECTURER (with a good honours degree or higher degree in chemistry and experience in industry, or teaching and research) IN CHEMISTRY—The Principal, Wigan and District Mining and Technical College, Wigan (July 4).

LECTURER IN THEORETICAL PHYSICS—The Registrar, The University, Manchester 13 (July 5).

RESEARCH ASSISTANT IN THE DEPARTMENT OF PHYSICAL AND INORGANIC CHEMISTRY, to undertake research and to assist with the supervision of Ph.D. students, either (*a*) in the field of physical adsorption; or (*b*) in the field of thermodynamics of solutions—The Registrar, The University, Bristol (July 5).

SENIOR LECTURER (medically qualified and with special qualifications in chemical pathology) IN CHEMICAL PATHOLOGY—The Registrar, The University, Manchester 13 (July 5).

DEMONSTRATOR IN PHYSICAL CHEMISTRY—The Registrar, The University, Hull (July 8).

LECTURER IN GEOLOGY—The Registrar (Room 22, O.R.B.), The University, Reading (July 12).

RESEARCH ASSISTANT (preferably with a good knowledge of biology and physical sciences) IN THE DEPARTMENT OF ANATOMY, for work mainly connected with electron microscopy—The Secretary, University College, Gower Street, London, W.C.1 (July 12).

RESEARCH ASSISTANT (with a good degree and preferably research experience in botany or biochemistry) IN THE DEPARTMENT OF BOTANY, to work on biochemical physiology—The Secretary, University College, Gower Street, London, W.C.1 (July 14).

ASSISTANT EXPERIMENTAL OFFICER (graduate) IN THE BEE DEPARTMENT, for work on field behaviour of bees—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (July 15).

LECTURER (with special experience in plant physiology) IN BOTANY—The Registrar, The University, Birmingham (July 15).

VOKES RESEARCH FELLOW IN THE DEPARTMENT OF MECHANICAL ENGINEERING, to undertake research in the field of filtration, the separation of mixtures, or allied problems in fluid mechanics—The Registrar, The University, Southampton (July 15).

DEMONSTRATOR IN THE DEPARTMENT OF GEOGRAPHY—The Secretary of the Appointments Committee, Department of Geography, The University, Downing Place, Cambridge (July 16).

RESEARCH WORKER (with a university degree, preferably in forestry, and some practical forestry and research experience), to continue the special study of shelterbelt problems in Scotland by the Department of Forestry—The Secretary, The University, Edinburgh (July 18).

RESEARCH ASSISTANT (graduate in zoology or candidate for honours this year) IN ZOOLOGY, to work on the biology of fish populations in the River Thames—The Registrar (Room 22, O.R.B.), The University, Reading (July 19).

ASSISTANT LECTURER or LECTURER IN CHEMISTRY—The Secretary, Royal College of Science and Technology, Glasgow (July 21).

SENIOR LECTURER IN BIOCHEMISTRY at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, July 21).

LECTURER IN THE DEPARTMENT OF PHYSIOLOGICAL CHEMISTRY—The Registrar (Room 22, O.R.B.), The University, Reading (July 31).

LECTURER or SENIOR LECTURER IN PATHOLOGY in the Faculty of Rural Science, University of New England, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (July 31).

LECTURER (preferably with special qualifications in applied mathematics) IN MATHEMATICS at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, July 31).

LECTURER (with an honours degree in zoology and preferably familiar with vertebrate zoology and an interest in the ecology of mammals) IN THE DEPARTMENT OF ZOOLOGY at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, July 31).

LECTURER IN SOCIAL ANTHROPOLOGY at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 10).

CHAIR OF BOTANY in the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 15).

LECTURER or SENIOR LECTURER IN POULTRY SCIENCE in the Faculty of Rural Science, University of New England, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (August 31).

CHEMIST (with an honours degree in chemistry or equivalent professional qualification plus a minimum of three years post-qualification experience) IN THE MEDICAL DEPARTMENT, Hong Kong, for general analytical and supervisory work—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.117/51/018/T.

LECTURER (with experience in rock and mineral analysis) IN THE PURE GEOCHEMISTRY SECTION OF THE GEOLOGY DEPARTMENT, for duties which will include teaching petrology and research in pure geochemistry or chemical petrology—Professor D. Williams, Geology Department, Imperial College, London, S.W.7.

PROFESSOR (familiar with gas turbines, jet propulsion and internal combustion engines) OF THERMODYNAMICS, for duties which will include lecturing to undergraduate and postgraduate students and the direction of research—The Dean of Engineering, Ecole Polytechnique (Canadian University), 1430 St. Denis Street, Montreal, Canada.

RESEARCH ASSISTANT IN THE CRYSTALLOGRAPHIC LABORATORY, for structure analysis of organo-metallic compounds—Secretary of the University of Cambridge, Department of Physics, Cavendish Laboratory, Free School Lane, Cambridge.

RESEARCH ASSISTANTS IN THE DEPARTMENTS OF BOTANY AND ZOOLOGY, CHEMISTRY, MATHEMATICS, METALLURGY AND PHYSICS—The Secretary, Sir John Cass College, Jewry Street, London, E.C.1.

SCIENTIFIC ASSISTANT (with a good science degree, a reading knowledge of two European languages (preferably other than French or German), ability to write good English, and preferably a knowledge of soil science and plant physiology), for work in a scientific information service involving abstracting and indexing—The Director, Rothamsted Experimental Station (Commonwealth Bureau of Soils), Harpenden, Herts.

SCIENTIST (with a first- or second-class honours degree in physics, physical chemistry or mathematics as a principal subject, and preferably with some previous experience in airborne dust measurement), for research on methods of assessing the dust content of the atmosphere, and the investigation of airborne dust conditions in mines, involving some underground work—Divisional Chief Staff Officer, National Coal Board, East Midlands Division, Sherwood Lodge, Arnold, Nottingham, quoting S.V.851.

SENIOR LECTURER (highly qualified in mathematics, considerable teaching and/or industrial experience, and preferably the ability to organize special courses in mathematics for highly qualified students in industry) IN MATHEMATICS—The Clerk to the Governors, South-East Essex Technical College, Longbridge Road, Dagenham.

REPORTS and other PUBLICATIONS

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Great Britain and Ireland

Planning, Vol. 24, No. 421 (14 April, 1958): The Debate on Sterling. Pp. 69–88. (London: Political and Economic Planning, 1958.) 2*s.* 6*d.* [164

Institution of Chemical Engineers. Proceedings of the Joint Symposium on the Scaling-Up of Chemical Plant and Processes, held at Church House, London, S.W.1, on 28 and 29 May, 1957. Edited by Dr. J. M. Pirie. Pp. 136. (London: Institution of Chemical Engineers, 1958.) 60*s.* [164

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Ministry of Housing and Local Government, and Scottish Office. The Surface-Water Year-Book of Great Britain, 1955–56: Hydrometric Statistics for British Rivers, together with related Rainfalls, for the year ended 30th September, 1956. Pp. xli+60. (London: H.M. Stationery Office, 1958.) 15*s.* net. [244

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Annual Report on the Progress of Rubber Technology, Vol. 21, 1957. Edited by Dr. T. J. Drakeley. Pp. xi+134. Cambridge: W. Heffer and Sons, Ltd., 1958. Published for the Institution of the Rubber Industry.) 25*s.* [244

Theoretical Chemistry: Looking Before and After. By Prof. D. P. Craig. (An Inaugural Lecture delivered at University College, London, 21 October, 1957). Pp. 14. (London: H. K. Lewis and Co., Ltd., 1958.) 2*s.* 6*d.* net. [244

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Imperial Cancer Research Fund. Fifty-Fifth Annual Report, 1956–1957. Pp. 45. (London: Imperial Cancer Research Fund, 1958.) [244

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 982, Vol. 250 (17 April, 1958): The Mobilities of Ions in Unlike Gases. By A. Dalgarno, M. R. C. McDowell and A. Williams. The Mobilities of Ions in their Parent Gases. By A. Dalgarno. (London: Royal Society, 1958.) 9s. [244

Agricultural Research Council: Soil Survey Research Board. Soil Survey of Great Britain—Report No. 9, 1956. Pp. 51. (London: H.M. Stationery Office, 1958.) 5s. net. [284

World Federation for Mental Health. Introductory Study No. 1: Identity. Pp. 46. (London: World Federation for Mental Health, 1958.) 5s. net. [284

Royal Institute of Chemistry. Lectures, Monographs and Reports, 1957. No. 5: Hydrazine and Its Derivatives. Edited by Dr. R. A. Reed. Pp. ii+50. 6s. net. No. 6: Lithium and Its Compounds. By Dr. D. A. Laidler. Pp. ii+34+4 plates. 5s. net. (London: Royal Institute of Chemistry, 1957.) [284

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Chicago Natural History Museum. Fieldiana: Geology. Vol. 10, No. 32: Fauna of the Vale and Choza, 14: Summary, Review, and Integration of the Geology and the Faunas. By Everett Claire Olson. Pp. 397–448. 1·25 dollars. Fieldiana: Zoology. Vol. 39, No. 11: The Races of the Shrike *Lanius validirostris*. By Austin L. Rand and D. S. Rabor. Pp. 85–86. 10 cents. Vol. 39, No. 12: The Races the Bush Shrike *Dryoscopus cubla*. By Austin L. Rand. Pp. 87–89. 10 cents. (Chicago: Chicago Natural History Museum, 1958.) [244

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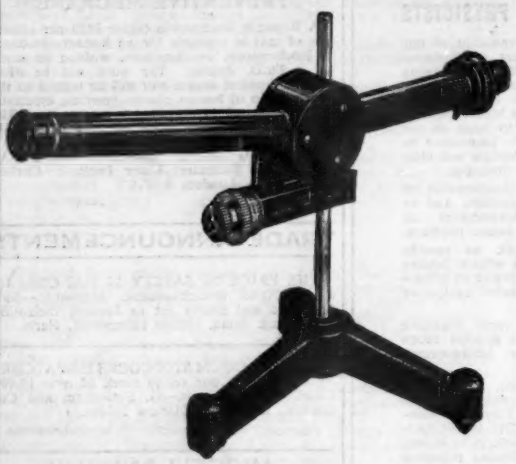

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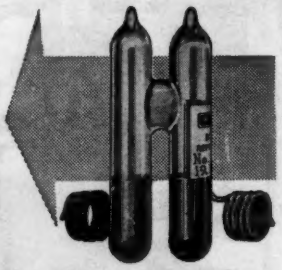

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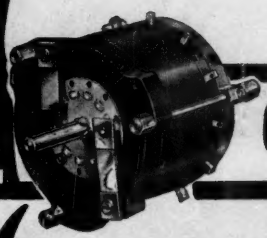

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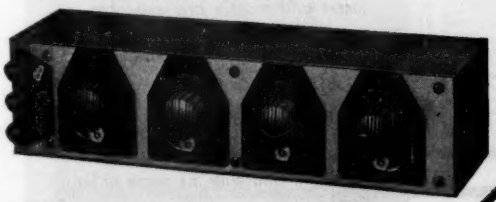

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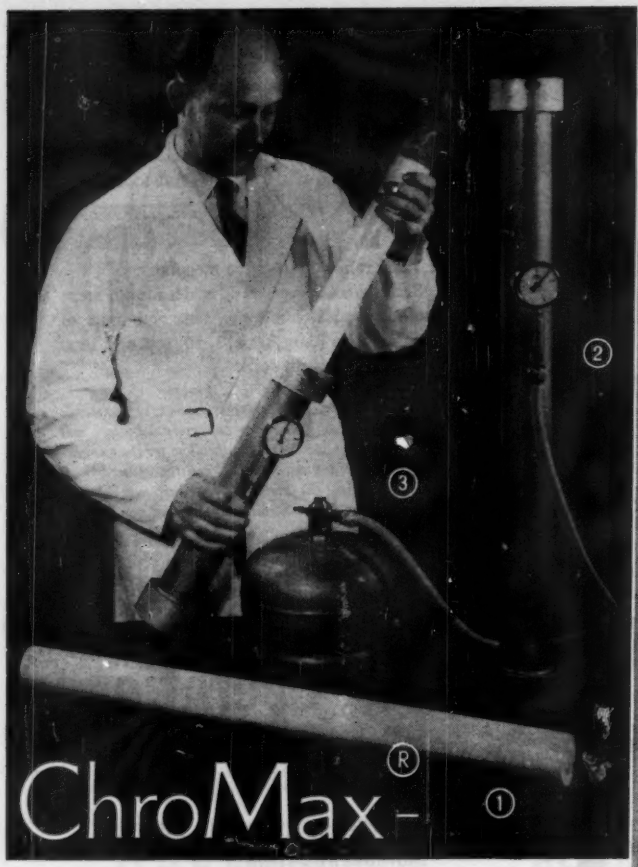

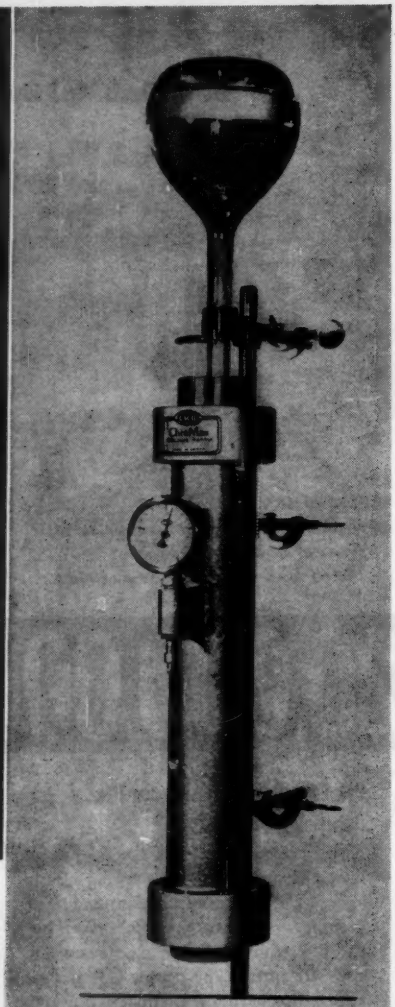

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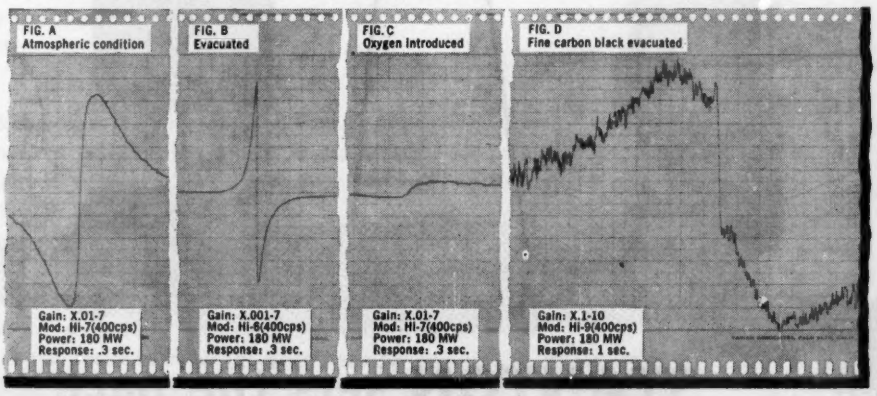

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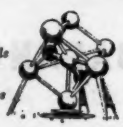

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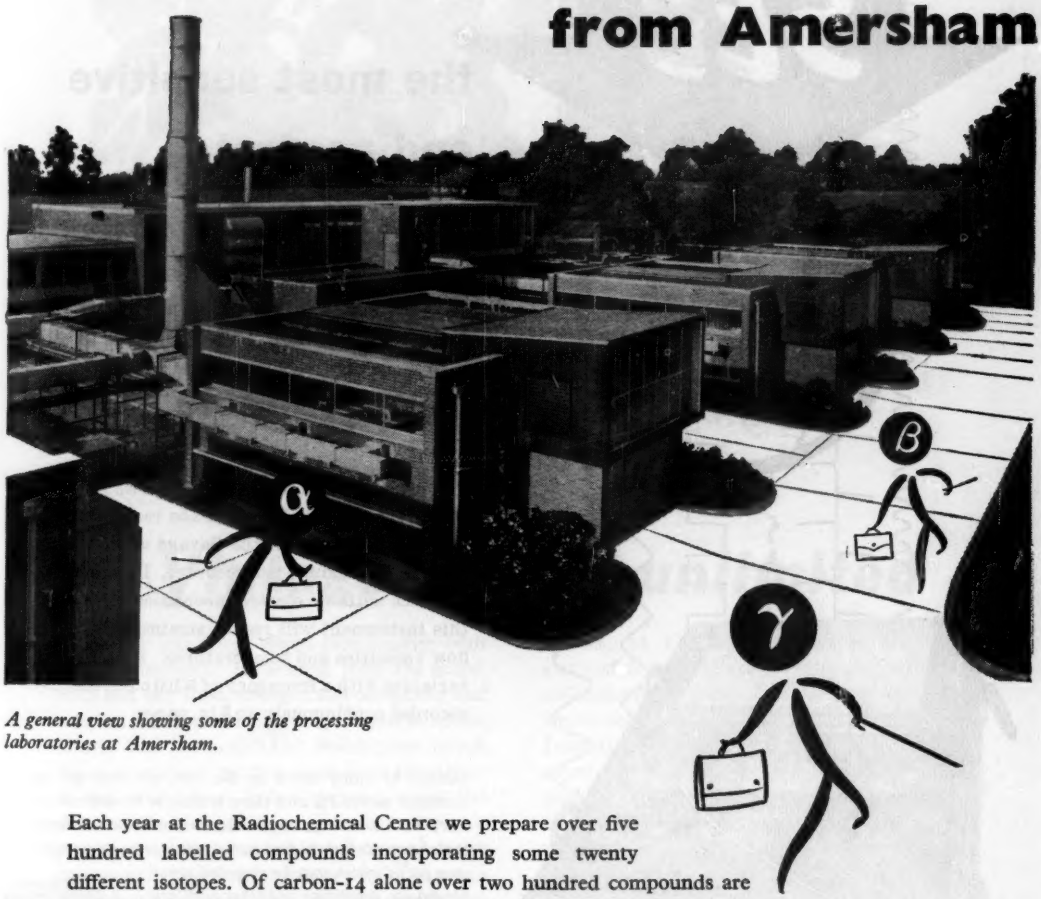

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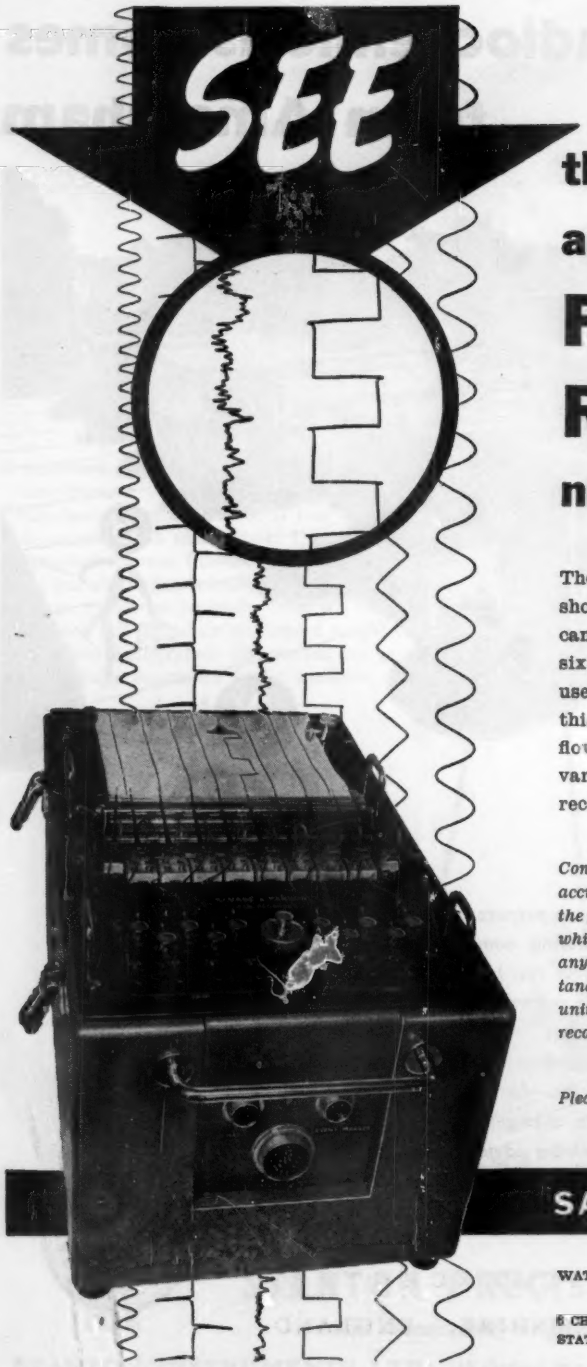

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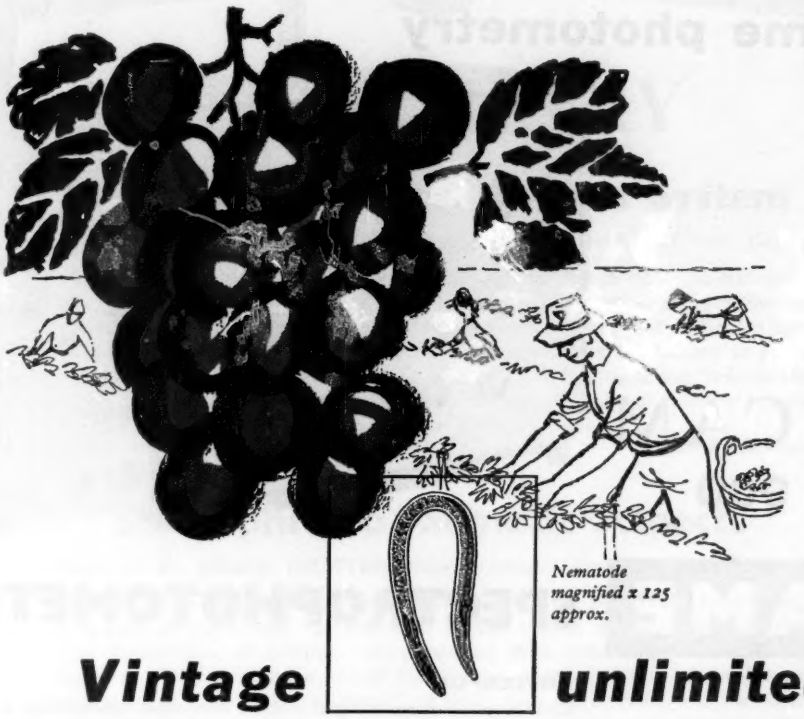

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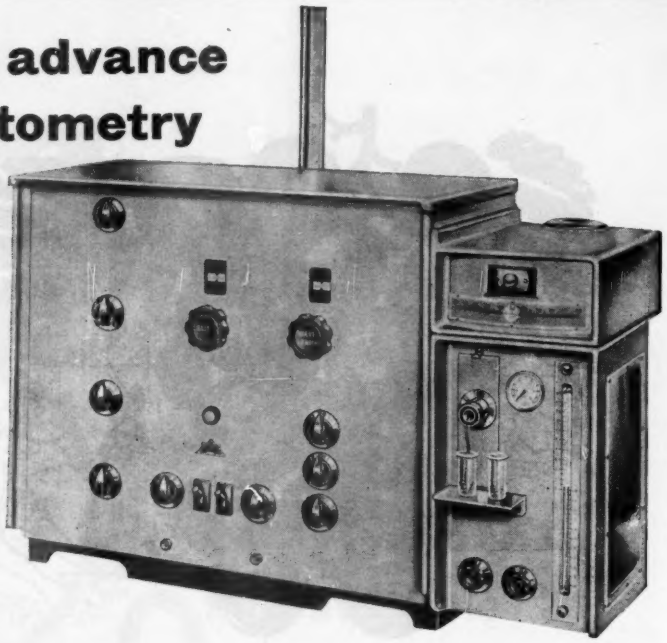

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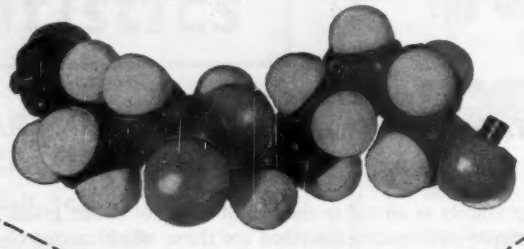

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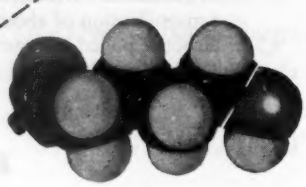

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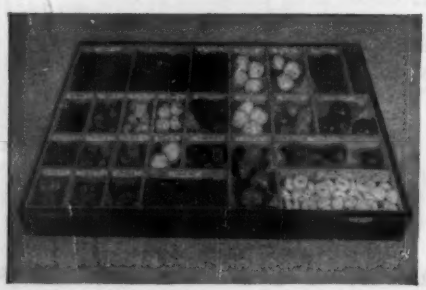

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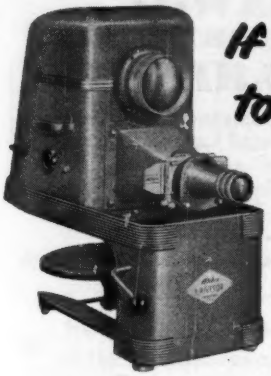

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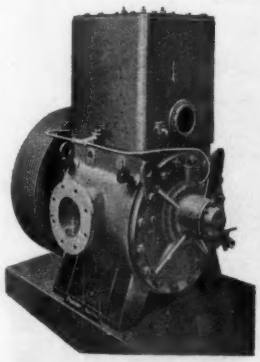

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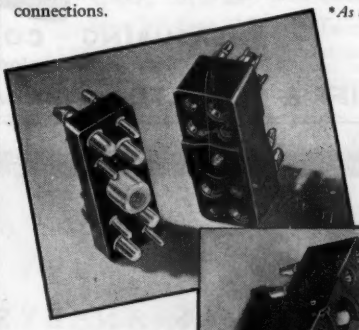

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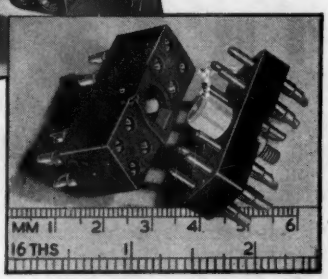

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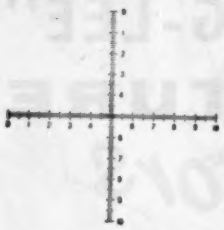

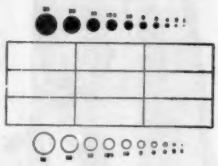

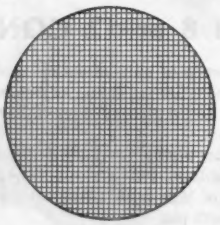

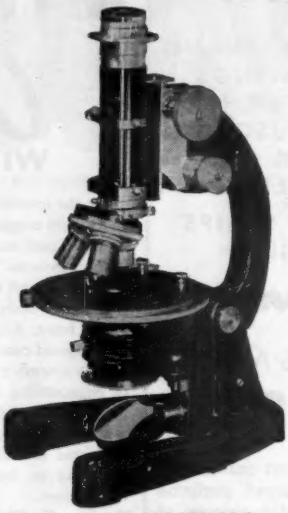

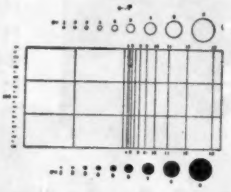

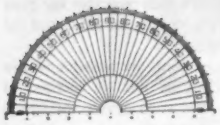

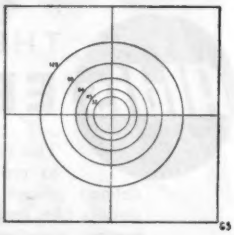

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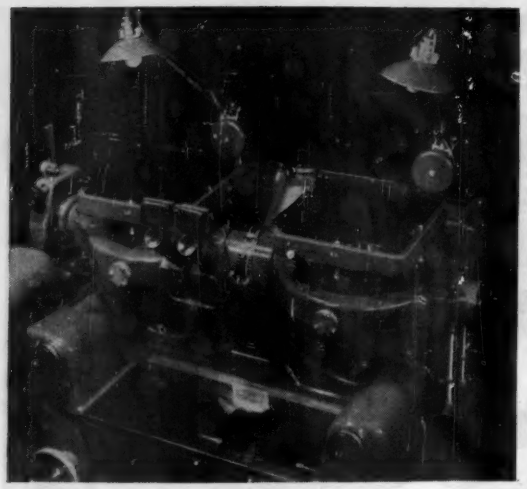

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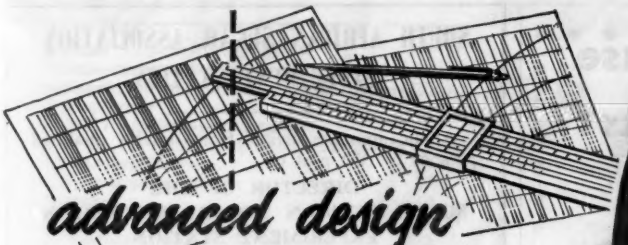

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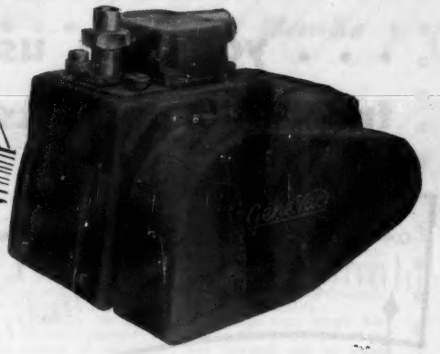

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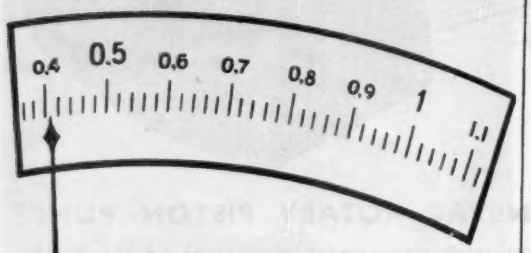

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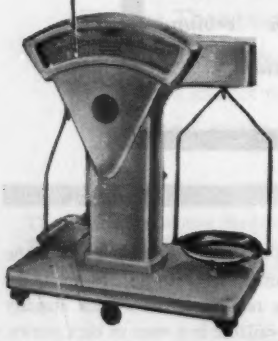

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Applications are invited from suitably qualified persons for the post of

DIRECTOR OF THE SOUTH AFRICAN SUGAR ASSOCIATION EXPERIMENT STATION

at Mount Edgecombe, Natal, 14 miles from Durban.

Applications must give full details of university degrees and other qualifications held and of posts occupied. They should, if possible, be accompanied by certified copies of at least two testimonials. Applicants should have general scientific experience, rather than specialized experience, with administrative ability and some administrative experience in research institutions. They should be between the ages of 35 and 45.

The duties involved will cover the general administration of the South African Sugar Association's Experiment Station at Mount Edgecombe, Natal, and its branches, including staff control and the direction and supervision of research programmes. Research covers all aspects of sugar cane agriculture only; sugar milling research is dealt with by a separate institute.

The salary for the post will be determined in accordance with the qualifications of the successful applicant, but will be not less than £3,000 per annum. The post carries pension rights, a free house, and free medical benefits. The successful applicant, if at present serving outside South Africa, will be offered a free passage to South Africa and, if he is a married man, his family's passage will be refunded after he has been confirmed in the appointment.

Applications should be addressed to the Chairman, S.A.S.A. Experiment Station Committee, P.O. Mount Edgecombe, Natal, South Africa, from whom any further information about the post may be obtained.

The closing date for applications is August 31, 1958.

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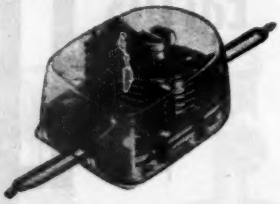

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2-Phenylanthracene (m.p.216° C.)	23	d
Picene	16	G
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Tetrophane	35	D
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Librarian, Ministry of Food, 1949–55
and D. J. FOSKETT, M.A., F.L.A.
Information Officer, Metal Box Co., Ltd., 1948–57

This bibliography sets out to demonstrate the wealth of material available to the food chemist and the food scientist. International in scope, it includes most of the significant works of authors on nutrition, food economics and food technology published in the English language, together with a representative selection of material from most foreign sources. Indeed, foreign literature coverage amounts to 30 per cent.

Only published material has been included. Material prepared privately by research and other organizations has not been listed, though the names and addresses of such organizations are included, giving added value to the work as a modern directory for the Industry. The book forms an essential reference tool for all engaged in work on nutrition, food and drink processing, food technology, distribution, packaging, economics, and the legal aspects of the food industry.

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This book is not concerned with the process of heat transfer itself, but with the apparatus performing this transfer and the best way of designing and fitting it into a gas turbine so as to obtain, depending on its application, an economical unit. It is felt that the manner in which the thermodynamical optimization of the gas turbine air preheater has been treated will be of particular interest in connection with supercritical steam cycles and nuclear power applications.

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LECTURES AND COURSES

MIDDLESEX COUNTY COUNCIL EDUCATION COMMITTEE

BRUNEL COLLEGE OF TECHNOLOGY
WOODLANDS AVENUE, ACTON, W.3
Principal: J. Topping, M.Sc., Ph.D., D.I.C., F.Inst.P.

DEPARTMENT OF CHEMISTRY
Head of Department: J. H. Skellon, T.D., M.Sc., Ph.D., F.R.I.C.

DIPLOMA IN TECHNOLOGY
SANDWICH COURSES IN APPLIED CHEMISTRY AND APPLIED BIOLOGY

The next courses commence on September 29, 1958. Firms and Research Associations are invited to send Industry-based students, and applications are also invited from College-based students for direct admission to the courses.

Applied Chemistry. Training in modern chemistry up to Honours Degree level with selected special training in High Polymer Chemistry or Radiochemistry or Special Analytical Chemistry or in the Chemistry of Oils, Fats and Waxes.

Applied Biology. Special subjects include Microbiology, Biochemistry, Parasitology and Pest Control and General Physiology.

All students spend alternate six month periods in College and Industry and undertake a project in their Final Year.

DEPARTMENT OF PHYSICS
Head of Department: C. A. Hogarth, B.Sc., Ph.D.

The following courses are among those to be held in the department during the session 1958-9. Autumn term begins September 22, 1958.

DIPLOMA IN TECHNOLOGY IN APPLIED PHYSICS

A four-year sandwich course commencing in January, 1959. Specialist subjects in the course include Nuclear Technology, X-ray Crystallography, Electronics, High Vacuum Technology, Electrical and Magnetic Properties of Solids.

B.SC. (GENERAL) DEGREE OF THE UNIVERSITY OF LONDON

The next part-time course begins in September, 1958, and extends over four years.

HIGHER NATIONAL CERTIFICATE IN APPLIED PHYSICS

Subjects include Electronics, High Vacuum Technology, Illumination, Applied Acoustics. New course begins in September, 1958, and is held on a day-release basis.

GRADUATESHIP OF THE INSTITUTE OF PHYSICS

A day-release course for holders of the Higher National Certificate in Applied Physics commencing in September, 1958, and extends over two years.

Evening courses to postgraduate standard are offered in the following subjects: Dislocations in Solids, Biological Effects of Nuclear and Allied Radiations, Ultrasonics, X-ray Crystallography, Physics of Nuclear Engineering, an Introduction to the Physics of Transistors.

Full details of courses and enrolment forms may be obtained from the Principal or appropriate Head of Department (ACOrn 6661).

C. E. GURR, M.Sc., Ph.D.,
Clerk to the Governing Body.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, S.W.3
DEPARTMENT OF CHEMISTRY
SESSION 1958-59

FULL-TIME COURSES LEADING TO GRADUATE MEMBERSHIP OF ROYAL INSTITUTE OF CHEMISTRY
COMMENCING SEPTEMBER, 1958

1. Applications are invited for a one year's course in preparation for Part II of the Graduateship examination. Candidates should have already gained exemption from Part I of the examination, or else expect to obtain such exemption during the summer of 1958. A few vacancies still remain.

2. A limited number of places will be available for suitably qualified students seeking entry to a two-year course leading, after the conclusion of the first session, to Part I of the Graduateship examination, and after the second session to Part II of the examination. Applicants should have completed (i) an adequate recognized course of Chemistry, and (ii) examinations in the compulsory ancillary subjects of Mathematics and Physics. The course offered in the first session will consist of Chemistry and the optional ancillary subject.

A college prospectus and forms of application may be obtained from the Head of the Department of Chemistry.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, S.W.3
DEPARTMENT OF GEOLOGY
Head of Department: W. E. Smith, M.Sc., F.G.S.

ORE-DRESSING

A course of ten lectures on the mineralogical aspects of ore-dressing will be given by Dr. E. Cohen on Wednesday evenings during the Autumn Term, 1958. The course is intended for graduates in Geology and metallurgists with a basic knowledge of mineralogy.

Further information may be obtained from the Head of the Department.

NORTHERN POLYTECHNIC

HOLLOWAY ROAD, LONDON, N.7
Principal: A. S. M. Symons, Ph.D., B.Sc., A.R.C.S., D.I.C., F.Inst.P.

Day and evening courses for the internal B.Sc. degree examinations of the University of London in chemistry, physics, mathematics, botany, zoology and geology. Full-time and Sandwich Courses for the Diploma in Technology in Applied Chemistry and Physics and for Grad.R.I.C. Facilities for research in science (full-time and part-time). Courses for the M.Sc. degree by written examination and dissertation in mathematics, physics and chemistry. Day and evening courses for the Grad.Inst.P. examinations. Courses are also conducted (day and evening) for the intermediate examination of the Pharmaceutical Society, and first medical examinations of the University of London, and for the general certificate of education. Next session begins September 22, 1958.

Prospectus on application. Tel.: NORth 1686.

UNIVERSITY OF BRISTOL

DIPLOMA IN HORTICULTURAL SCIENCE
DIPLOMA IN PLANT PATHOLOGY (including ENTOMOLOGY) and PROTECTION

The above postgraduate diploma courses will be available during the session 1958-9. Conducted in part at the Long Ashton Research Station, they are intended primarily for those with good honours degrees in science who seek careers in horticultural research, at home or overseas. The course in Plant Pathology and Protection permits specialization in any approved branch of the subject, including applied entomology. The Horticultural Science course commences on September 15, the Plant Pathology course on September 29. Both courses extend over a full session of three terms ending in June or July, and include some additional practical work during the vacations.

Applications are invited from graduates in botany or general science for the Horticultural Science course, and in zoology (for applied entomology) or chemistry (for crop protection) for the Plant Pathology Course. Entry forms and full particulars may be obtained from the Registrar, The University, Bristol, 8.

OFFICIAL APPOINTMENTS

PLYMOUTH, S. DEVON AND E. CORNWALL HOSPITAL MANAGEMENT COMMITTEE

AREA PATHOLOGY LABORATORY

Applications are invited from suitably qualified persons for the post of non-medical Biochemist, senior grade, in this Laboratory, at the Greenbank Road Hospital, Plymouth.

Applications stating age, nationality, qualifications and experience, with names and addresses of three referees, to be sent to the Group Secretary, 7 Nelson Gardens, Stoke, Plymouth.

UNIVERSITY OF EDINBURGH AND SOUTH-EASTERN REGIONAL HOSPITAL BOARD

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Applications to Director of Unit, 12 George Square, Edinburgh, 8, giving names of two referees.

KUMASI COLLEGE OF TECHNOLOGY

(Principal: W. E. Duncanson, Ph.D., D.Sc., F.Inst.P., A.M.I.E.E.)

Applications are invited for the following appointments: (a) Senior Lecturer or Lecturer in Electric Power Machines. (b) Senior Lecturer and Lecturer in Electrical Engineering. The College prepares students for the London University B.Sc. degree in Engineering and for the examinations of the professional Engineering Institutions. Qualifications: Good honours degree; A.M.I.E.E., or equivalent professional qualification; industrial and teaching experience in the case of those applying for the Senior Lectureships. Appointment may be accepted on contract for five years or on pension. Arrangements to continue policies initiated under F.S.S.U. scheme might be made by the College. Contract salary scales: Senior Lecturer, £2,125 by £75 to £2,425 per annum; Lecturer, £1,281 5s. by £62 10s. to £2,031 5s. per annum, plus gratuity payable at end of contract at the rate of £12 10s. for each month of satisfactory service. Pensionable and F.S.S.U. salary scales: Senior Lecturer, £1,580 by £60 to £1,940 per annum; Lecturer, £925 by £50 to £1,625 per annum. Point of entry according to experience. Children's allowances up to a maximum of three at the rate of £50 per annum per child up to 10 years, and £100 per annum per child over 10 years in full-time education up to 21 years. Annual leave with free return first-class passages for member of staff and, conditional on minimum stay in West Africa, his wife and up to three children under 17 years. Bungalows with basic furniture at low rental provided. Income tax low.

Applications (six copies), giving age, education, qualifications, experience and the names of three referees, should be sent to the Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2. Closing date July 4, 1958.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, LONDON, S.W.3
DEPARTMENT OF PHYSIOLOGY AND PHARMACOLOGY
Head: Mary F. Lockett, M.D.(Lond.), M.R.C.P., Ph.D.(Cantab.).

The Governing Body invite applications for the post of Lecturer or Assistant (Grade B) in Physiology or Pharmacology. Honours degree essential. Duties include teaching and research. The successful candidate will be graded as Lecturer or Assistant (Grade B) in accordance with qualifications and experience. The salary scales attached to the grades are as follows: (a) Lecturer, men, £1,200 by £30 to £1,350; women, £1,097 3s. to £1,350, plus London allowance of £36 or £48 according to age. Placing on the scale will be in accordance with previous service in a similar capacity. (b) Assistant, Grade B, men, £650 by £25 to £1,025; women, £620 to £1,025, plus additions for training (men £25 to £75; women £20 to £60). Graduate status (men £75; women £60). Honours addition (men £50; women £40) and London allowance of £36 or £48 according to age. Placing on the scale will be in accordance with previous service in a similar capacity and/or industrial experience.

Particulars and form of application from the Clerk to the Governors. Applications to be submitted by July 11, 1958.

UNIVERSITY COLLEGE OF GHANA

Applications are invited for Chair of Botany, tenable from January, 1959. Salary £2,500 per annum. Outfit and family allowances. F.S.S.U. passages for appointee and family on appointment, normal termination and annual overseas leave Part-furnished accommodation at rent not exceeding 7.5 per cent of salary.

Detailed applications (eight copies), naming three referees, by August 15, 1958, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

UNIVERSITY OF BIRMINGHAM

DEPARTMENT OF BOTANY

Applications are invited for a Lectureship in Botany (£900 to £1,650). The appointment will commence on October 1, 1958. Special experience in plant physiology is desirable, but the Lecturer appointed will be expected also to take an equal share in the general botanical teaching of the first two undergraduate years.

Applications (two copies), giving age, qualifications, and the names and addresses of two referees, should be sent by July 15, 1958, to the Registrar, the University, Birmingham, 15, from whom further particulars may be obtained.

COMMONWEALTH of AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION DIVISION OF RADIOPHYSICS VACANCIES ON SCIENTIFIC STAFF

The Division of Radiophysics, which is situated within the grounds of Sydney University, has vacancies on its scientific staff for a Research Officer and an Experimental Officer for interesting work on the development of radio aids to aerial navigation.

Appointment Number 780/184. Applications are invited for appointment as a Research Officer to devise, design, and develop special aerials and associated electronic equipment forming part of an overall system to provide D.M.E.-equipped aircraft with an indication of their heading. Applicants should possess a university honours degree in engineering or science, or equivalent qualifications, together with a sound knowledge of modern electronic and u.h.f. techniques, and should be able to show evidence of some years of postgraduate research experience. Dependent upon qualifications and experience, commencing salary will be determined within the salary range of £A.1,326 to £A.1,951 per annum Research Officer. Salary for a female appointee would be £A.170 per annum less than the corresponding male rates.

Appointment Number 780/185. Applications are invited for appointment as Experimental Officer to take part in the development and testing of the component parts for a system such as is mentioned in the preceding paragraph, and to assist in the flight trials of the system as a whole. Applicants should have completed a university degree in engineering or science, or a technical college diploma course in radio or electrical engineering, should possess a good knowledge of modern electronic and/or u.h.f. techniques, and have had practical experience in at least one of these fields. Dependent upon qualifications and experience, appointment will be made within the salary ranges of Experimental Officer, Grade I, £A.966 to £A.1,416, or Grade II, £A.1,416 to £A.1,686. (£A.170 per annum less for a female appointee.)

The appointments will, in the first instance, be for a period of two years, but with the possibility of extension on a more permanent basis at the end of that time and they will be conditional on a satisfactory medical examination. Appointees migrating from overseas will be eligible for first-class in the case of Research Officer and tourist class for Experimental Officer, sea or air transport to Australia for himself, his wife and family. An appropriate contribution will also be made towards the fares of an Australian appointee, his wife and family, temporarily abroad for study or similar purposes.

Applications, quoting Appointment No. 780/184 or 780/185 and stating full name, place, date and year of birth, nationality, marital state, present employment, details of qualifications and experience, and of war service, if any, together with the names of not more than four persons acquainted with the applicant's academic and professional standing, should reach the undersigned, from whom further particulars may be obtained, not later than July 18, 1958.

A. SHAVITSKY,
Chief Scientific Liaison Officer.

Australian Scientific Liaison Office,
Africa House, Kingsway,
London, W.C.2.

UNIVERSITY OF TORONTO

DEPARTMENT OF MATHEMATICS

Applications are invited for positions as Lecturers in Mathematics with duties to begin September 15, 1958. The salary is $5,100 or better per annum depending upon qualifications and experience. The fields of competence preferred are applied mathematics and analysis.

Applications should be addressed to Professor D. B. DeLury, from whom further particulars can be obtained.

NORTHERN POLYTECHNIC

HOLLOWAY, LONDON, N.7

The Governing Body invite immediate applications for the undermentioned posts:

(a) Lecturer in Mathematics. To teach up to B.Sc. General, Part II, standard.

(b) Lecturer in Chemistry, with special reference to Inorganic Chemistry, to teach to B.Sc. Honours standard. Industrial or research experience desirable.

Salary scale: men, £1,200 by £30 to £1,350; women, £1,097 by equal pay increments to £1,350; plus London allowance.

Apply, stating appointment in which interested, for form of application and further particulars to the Clerk to the Governors.

CITY AND COUNTY OF KINGSTON UPON HULL

WATER DEPARTMENT

APPOINTMENT OF CHEMIST AND MICROBIOLOGIST

Applications are invited for the appointment of a Chemist and Microbiologist to supervise and control a new river water treatment plant, capacity 12 m.g.d.

Candidates must hold a degree in natural science from a recognized university or equivalent qualification and must produce evidence of a thorough knowledge of chemistry, bacteriology, and biology as applied to water; have experience of water treatment by coagulation and chlorination methods, and be conversant with the biology and management of storage reservoirs.

The duties of the officer appointed will include analysis of water samples at all stages of purification from the river to the distribution system and the daily control of the water treatment plant.

The officer will be under the general direction of the Water Engineer and Manager, who may allot such other analyses, investigations, and duties from time to time.

The person appointed will be required to reside on the site, where housing accommodation will be provided at a reasonable rent.

The salary will be within Grade V, A.P.T. Division of the National Joint Council's Scales (£1,175 to £1,325 per annum) according to qualifications and experience.

The whole of the candidate's time will be required to be devoted to the service of the Water Department.

The appointment will be subject to one month's notice on either side, to the National Scheme of Conditions of Service, and, being superannuable, will be subject to the passing of a medical examination.

Applicants should state age and give details of education, training, experience, and present and previous appointments.

Applications, with copies of two recent testimonials, are to be received by the undersigned not later than 10 a.m. on Monday, July 14, 1958.

Canvassing a member of the City Council or any Chief Officer will be a disqualification.

T. H. JONES, M.I.C.E.,
Engineer and Manager.

Water Department,
Alfred Gelder Street,
Kingston upon Hull.

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To organize and take charge of the economic section of the administrative division of the Ministry of Agriculture, Kaduna. Candidates must have a good honours degree in economics. A postgraduate qualification in agricultural economics or experience of field research in agriculture an advantage. Appointment on probation to the permanent establishment with pensionable emoluments in scale £804 to £1,680 per annum or on contract/gratuity terms if preferred. Outfit allowance £45. Free passages on appointment and leave for officer and wife. Assistance towards cost of children's passages. Furnished Government quarters at moderate rental normally available. Generous leave.

Apply, giving brief particulars, to Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/408/07.

CYCLOTRON RADIOCHEMIST REQUIRED to take charge of chemical aspects of radioisotope production for medical research, in collaboration with existing engineering and physics teams. Candidates should hold a good degree in chemistry and preferably have some experience of radiochemistry. Salary according to age and qualifications between £750 and £900 per annum. F.S.S.U. and child allowances.—Detailed applications should be addressed to Director, Medical Research Council, Radiotherapeutic Research Unit, Hammersmith Hospital, Ducane Road, W.12.

RUBBER RESEARCH INSTITUTE OF MALAYA

KUALA LUMPUR, FEDERATION OF MALAYA VACANCY FOR STATISTICIAN

The Board of the Rubber Research Institute of Malaya invites applications for the post of the Head of the Statistics Section of the Institute at Kuala Lumpur, Malaya. Applicants should have high academic qualifications and considerable statistical research experience. The duties will include design of field and laboratory experiments and the conduct of research in statistical matters relating to all branches of the Institute's work. The appointment will be made on the Research Officer's scale, the point of entry being according to age, qualifications, and experience. A suitable candidate with the required qualifications will be appointed in the upper half of the salary scale, which is:—Time scale: basic salary, £1,400 to £2,660 per annum, with annual increments of £70. Super scale (by selection): basic salary, £2,870 to £3,080 to £3,290 per annum. Fixed allowances, £630 per annum; additional allowance per child, £140 per annum, salaries and allowances are paid in Malayan currency. Quarters with heavy furniture, medical attention, and passages for wife and two children under 18 years of age are provided.

Application forms and more detailed information may be obtained from the Secretary, London Advisory Committee for Rubber Research (Ceylon and Malaya), Commonwealth Institute, Imperial Institute Road, London, S.W.7, to whom completed applications should be sent by July 31, 1958.

CENTRAL ELECTRICITY GENERATING BOARD

METALLURGIST—RESEARCH LABORATORIES

METALLURGIST required at RESEARCH LABORATORIES, Leatherhead, Surrey, to assist in investigating unusual problems in the creep of metals used in nuclear power generation. Candidates should be L.I.M. or hold the H.N.C. in metallurgy or physics. Experience in conventional creep testing will be a recommendation, but applicants without experience in this field will be considered. Salary will be within scales £820 to £995 per annum or £550 to £725 per annum, according to qualifications and experience.

Applications, stating age, qualifications, experience, and present position and salary, should be forwarded to S. S. Scott, Chief Personnel Officer, 24/30 Holborn, London, E.C.1, by July 10. Envelopes should be marked "Confidential"—Ref. N./167.

MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY

APPOINTMENTS IN METALLURGY

Applications are invited for the undermentioned posts in the Metallurgy Section of the Department of Chemical Engineering. Candidates, who must be graduates or hold an equivalent qualification, should have specialized knowledge and experience in one of the following: Foundry Practice, Metallurgical Analysis, Refractories, Non-ferrous Extraction or Physical Metallurgy. Salary scales: Senior Lectureship,, £1,350 by £50 to £1,550; Two Lectureships, £1,200 by £30 to £1,350; Two Assistant Lectureships, £650 by £25 to £1,025 plus graduate and training allowances where appropriate.

Application forms and further particulars may be obtained from the Registrar, the Manchester College of Science and Technology, Manchester, 1, to whom they should be returned by July 5, 1958.

B. V. BOWDEN,
Principal of the College.

ST. LUKE'S HOSPITAL

GUILDFORD

Assistant Physicist in the Radiotherapy Centre on the basic scale £625 to £1,000 according to experience. This is an expanding Centre where both stationary and moving beam techniques are employed. A 1,500 c. cobalt unit is on order. Candidates should have a first- or second-class honours degree and previous experience is desirable.

Applications, with names of two referees, should be sent to the Medical Superintendent.

UNIVERSITY OF HULL

Applications are invited for a Demonstrator in Physical Chemistry, to commence on September 1, 1958. Salary £450 to £550 per annum.

Applications (five copies) should reach the undersigned, from whom further particulars may be obtained, as soon as possible, and not later than July 8, 1958.

W. D. CRAIG,
Registrar.

CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH AND DEVELOPMENT DEPARTMENT

PHYSICISTS required in the Research and Development Department at Headquarters, London, S.E.1.

Successful applicants will be concerned with work on nuclear reactors, in many cases of a practical nature, and including the reactor physics commissioning programme, reactor core design, reactor control and fuel cycling. The posts will call for collaboration with laboratory and design staffs of this and other organizations.

A good honours degree in physics is desirable and candidates must also have a sound experimental physics background. Previous practical experience in nuclear physics will be an advantage, although this is not essential as training may be given in suitable cases. In the first instance the posts will be located at London Headquarters, Bankside House, London, S.E.1, but subsequently the Physicists will be attached to the Board's laboratories and nuclear power stations as the need arises.

Salaries will be on scales within the following overall ranges according to qualifications and experience:

£550 to £1,265 per annum.
£1,160 to £1,735 per annum.
£1,490 to £1,945 per annum.

plus London allowance when appropriate.

Application forms, obtainable from S. S. Scott, Chief Personnel Officer, 24-30 Holborn, London, E.C.1, should be returned by July 21. Envelopes should be marked "Confidential—ref. N./175."

UNIVERSITY OF SYDNEY

AUSTRALIA

Applications are invited for the position of Lecturer in Mathematical Statistics. The salary for a Lecturer is within the range £A.1,500 by £A.90 to £A.2,100 per annum, plus cost of living adjustment (at present £A.11 per annum for men, £A.8 per annum for women), and will be subject to deductions under the State Superannuation Act. The commencing salary will be fixed according to the qualifications and experience of the successful applicant. Under the Staff Members' Housing Scheme in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. The closing date for the receipt of applications, in Australia and London, is August 2, 1958.

UNIVERSITY OF SYDNEY

AUSTRALIA

Applications are invited for the position of Lecturer in Chemistry. Teaching duties will mainly be with first-year classes. The salary for a Lecturer is within the range £A.1,500 by £A.90 to £A.2,100 per annum, plus cost of living adjustment (at present £A.11 per annum men, £A.8 per annum women) and will be subject to deductions under the State Superannuation Act. The commencing salary will be fixed according to the qualifications and experience of the successful applicant. Under the Staff Members' Housing Scheme, in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. The closing date for the receipt of applications, in Australia and London, is August 4, 1958.

UNIVERSITY OF SHEFFIELD

Applications are invited for a post of Lecturer in the Postgraduate Department of Applied Mechanics to begin duties on January 1, 1959. Salary scale £900 by £50 to £1,350 by £75 to £1,650, with F.S.S.U. provision and family allowance. Initial salary according to qualifications and experience.

Further particulars should be obtained from the Registrar, to whom applications (four copies), should be sent by July 19, 1958.

APPLICATIONS ARE INVITED FOR A LECTURESHIP in the Department of Physiological Chemistry for work connected with soil science; the appointment may be in Grade I or Grade II and will date from September 30, 1958, or as soon thereafter as possible.—Further particulars may be obtained from the Registrar (Room 22, O.R.B.), the University, Reading, by whom applications should be received not later than July 31, 1958.

MAKERERE COLLEGE

UNIVERSITY COLLEGE OF EAST AFRICA

Applications are invited for (a) Lectureship or (b) Assistant Lectureship in Botany, preferably from candidates with interest in physiology and ecology. Salary scales: (a) £1,107 by £42 to £1,149 by £45 to £1,284 by £51 to £1,335 by £54 to £1,389 by £57 to £1,617 per annum, (b) £939 by 42 to £1,065 per annum. Entry point determined by qualifications and experience. F.S.S.U. Child allowance £50 per annum per child (maximum £150 per annum). Passages for appointee and family (up to four adult passages) on appointment, termination, and leave (three months every 21 months). Rent according to quarters provided, £45 to £84 per annum (including basic furniture).

Detailed applications (six copies), naming three referees, as soon as possible to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

SENIOR SCIENTIFIC/ SCIENTIFIC OFFICERS

required by

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON

BERKSHIRE

to join a team of chemists and chemical engineers making fundamental and applied research studies in the organic chemical field, covering investigations on preparative methods of specialized materials, and physico-chemical problems arising from production and research programmes. Second-class honours degree in chemistry is minimum qualification: for one of the posts physical chemistry or applied physics experience or qualifications an advantage. Successful applicants for the senior grade will control a section of staff and will need to work closely with other members of the team.

Salary: Senior Scientific Officer, £1,215 to £1,425 per annum; Scientific Officer—to be assessed according to qualifications and experience within the scale £645 to £1,120 per annum.

Contributory superannuation scheme. A house, or assistance towards legal expenses on house purchase, will be available for married officers living beyond daily travelling distance.

Postcards for application forms to the Senior Recruitment Officer at above address. Please quote ref. 1897/34.

UNIVERSITY COLLEGE OF RHODESIA AND NYASALAND

Applications are invited for Lectureship in Mathematics. Salary scales: Assistant Lecturer, £1,050 by £50 to £1,200 per annum; Lecturer (Grade II), £1,200 by £50 to £1,450 per annum, (Grade I) £1,450 by £50 to £1,750 per annum, entry point determined by qualifications and experience. Superannuation scheme. Passages to Salisbury for appointee, wife and dependent children on appointment with allowance for transport of effects. Unfurnished accommodation at rent of up to 15 per cent of salary. Assistance given for triennial leave overseas.

Detailed applications (six copies), naming three referees, by August 20, 1958, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

UNIVERSITY OF BIRMINGHAM

DEPARTMENT OF CIVIL ENGINEERING

Applications are invited for a Lectureship in Civil Engineering. Salary within the range £900 to £1,650 according to qualifications and experience. The Lecturer will be required to take up his duties by October 1, 1958. The Lecturer would be required to undertake teaching in theoretical and applied elasticity or fluid mechanics. Time and facilities would be available for research work. Applicants should possess a good honours degree in applied mathematics or engineering science; research experience is very desirable.

Applications (two copies) should be submitted by July 14, 1958, to the Registrar, the University, Birmingham, 15, from whom further particulars may be obtained.

NORTH OF SCOTLAND COLLEGE OF AGRICULTURE

The Governors invite applications for the following posts:

Advisory Officer in Animal Husbandry. Candidates should possess a degree in science or agriculture, preferably with honours, and should have had experience in investigational and advisory work. Salary scale: (men), Grade II, £1,285 to £1,480, or (men), Grade III, £810 to £1,280.

Advisory Officer in Poultry Husbandry. Candidates should possess a degree in science or agriculture, preferably with honours, and should have had experience in investigations or research concerning poultry husbandry. Salary scale: (men), Grade II, £1,285 to £1,480, or (men), Grade III, £810 to £1,280.

Assistant Resident Supervisor for Certificate Course in Agriculture. Candidates should possess a degree in agriculture and should have special interest in animal husbandry. The appointee will require to undertake lecturing, practical instruction, tutorial and hostel duties. Salary scale: (men), Grade IVa, £595 to £800, or (men), Grade IVb, £575 to £800. The salary will be abated, in respect of board and accommodation, by a sum of £100, which is subject to review.

All the above posts are subject to superannuation.

Forms of application, which can be obtained from the Secretary of the College at 41½ Union Street, Aberdeen, should be lodged not later than July 10, 1958.

UNIVERSITY OF OXFORD

Applications are invited for the post of Research Assistant in the Unit of Biometry. The appointment is supported by a grant from the Agricultural Research Council and will be for one year in the first instance. The chief duties will be concerned with the design and analysis of radiobiological experiments in conjunction with the Agricultural Research Council radiobiological laboratory at Grove. There will also be opportunities for experience of other types of statistical consulting work. Salary will be according to age, experience and qualifications on a scale equivalent to that of Scientific Officer, with F.S.S.U. benefits. The successful applicant will be required to take up the appointment on or before October 1, 1958. Candidates should have at least a second-class honours degree in statistics or in mathematics with a certificate or diploma in statistics.

Two copies of applications, giving age, qualifications and experience, etc., should be sent to the Reader in Biometry, 7 Keble Road, Oxford, to reach him not later than July 19, 1958.

COMMONWEALTH BUREAU OF SOILS

Rothamsted Experimental Station, Harpenden, Herts. Scientific Assistant required for work in scientific information service involving abstracting and indexing. Good science degree, reading knowledge of two European languages (preferably other than French or German) and ability to write good English are essential. Knowledge of soil science and plant physiology an advantage. Salary scale £595 to £970 (bar) to £1,330 (bar) to £1,460. Qualifications, experience, National Service and age will be considered when fixing the starting salary. Two extra increments will be given on completing two years' satisfactory service for those aged 32 and under. Superannuation according to F.S.S.U.

Apply at once to Director, stating age, qualifications and experience.

D.S.I.R. MECHANICAL ENGINEERING Research Laboratory, Plasticity Division, East Kilbride, Glasgow, requires Senior Scientific Officer or Scientific Officer to take charge of team working on high pressure physics. Research ranges from study of mechanical and physical properties of materials under high fluid pressures to production of materials with new and unusual properties by application of high pressures and temperatures. Qualifications, first- or second-class honours degree in physics or engineering or equivalent. Knowledge of work involving high pressure fluids, miniature precision mechanisms, strength of materials, or metal physics an advantage. Salary ranges: Scientific Officer, £595 to £1,050; Senior Scientific Officer (minimum of three years postgraduate experience), £1,130 to £1,330. Prospects of promotion to Principal Scientific Officer, £1,370 to £1,950, and for candidates under 31 also of establishment. Houses available for married staff.—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1 (quote A.226/8A).

SCUNTHORPE HOSPITAL MANAGEMENT COMMITTEE

LINCOLNSHIRE RADIOTHERAPY CENTRE
SCUNTHORPE AND DISTRICT WAR MEMORIAL HOSPITAL

Medical Physicist required. Appointment is in Senior Grade but applications will be considered from Basic Grade candidates. Candidates should possess a first- or second-class honours degree in physics. Salary scale: Senior Grade, £1,100 by £50 (8) to £1,500 per annum. Basic Grade (probationary period), £625 by £25 to £700 and after two years £800 to £1,000. Postgraduate study or experience may be considered in fixing the starting salary but previous hospital experience is not essential. The Centre is scheduled for transfer to Lincoln where a new treatment Unit will be built incorporating telecobalt therapy and a fully equipped isotope therapy and tracer laboratory. Special consideration will be given by the Local Authority regarding housing accommodation for married candidates.

Applications, stating age, qualifications and previous experience, together with the names of two referees, should be forwarded to the Group Secretary, Scunthorpe Hospital Management Committee, Scunthorpe and District War Memorial Hospital, Scunthorpe, Lincs.

SOUTH-WEST ESSEX TECHNICAL COLLEGE

FOREST ROAD, LONDON, E.17

Required in September, an Assistant Grade B (man) to teach theoretical and practical Physics to B.Sc. General Degree students. Salary: £650 by £25 to £1,025, plus London allowance with additions for degree (or equivalent) and approved training. Increments within scale for previous teaching service, approved industrial experience and War/National Service.

Applications (no forms), by letter, giving particulars of qualifications, training and experience, and enclosing copies of three recent testimonials or giving the names and addresses of three referees, to be submitted to the Clerk to the Governors at the College.

MID-ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART

MARKET ROAD, CHELMSFORD

Required from September 1, 1958, or as soon after as possible, Assistant, Grade B, for Mathematics. Applicants should be graduates, and some previous teaching experience is desirable. Duties will involve work in degree and H.N.C. Courses. Salary: £650 by £25 to £1,025 with additions for degree (or equivalent) and approved training. Increments within scale for previous teaching service, approved industrial experience, and War/National Service. Commencing salary could be £900 per annum or more.

Details and forms (stamped addressed foolscap envelope) from the Clerk to the Governors at the College.

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF ELECTRICAL ENGINEERING

Applications are invited for the appointment of Lecturer in Electrical Engineering who will be required to specialize in the field of electrical power systems (high voltage, protection, system stability, etc.). Candidates should have a good honours degree in electrical engineering and preferably some industrial experience. Salary within the scale £900 to £1,650 according to qualifications and experience.

Conditions of appointment and form of application, which should be returned by Saturday, July 19, 1958, from the Registrar.

ST. MARY'S HOSPITAL

PADDINGTON, W.2

Junior Technician for Biochemical Work in conjunction with studies using a heart-lung machine and the artificial kidney. Facilities for general clinical biochemical work are excellent and the special work is mainly concerned with blood-gas analysis and electrolyte estimations, including isotope studies. Whitley salary and conditions.

Apply, in writing, giving age, education and experience, with the names of two referees, to Alan Powditch, House Governor.

THE ROYAL INSTITUTE OF PUBLIC Health and Hygiene invites applications for the post of Industrial Hygienist to the Laboratories of the Institute, 23 Queen Square, London, W.C.1. Starting salary not less than £1,500 per annum. Superannuation fund available.—Applications, stating age, qualifications, and experience, to the Secretary, 28 Portland Place, W.1, not later than July 31, 1958. Further particulars may be obtained from the Secretary.

DEPARTMENT OF AGRICULTURE

NEW SOUTH WALES, AUSTRALIA
SOIL SURVEYORS

Applications are invited for appointment as Soil Surveyors with the New South Wales Department of Agriculture. Salary £A.1,081 range £A.1,771 per annum. Commencing rate according to qualifications and experience. Prospects of progression to £A.2,006 per annum. B.Sc.(Agr.) or equivalent qualification required. Duties include carrying out soil surveys in any part of New South Wales, preparation of data and draft maps from surveys, laboratory work, etc. Headquarters may be at Sydney or at country centres as required. Subject to medical fitness, appointees will be eligible to contribute to the New South Wales Superannuation Fund. Arrangements will be made for appointees and their families to be nominated for travel to Sydney under the Assisted Passage Migration Scheme.

Further particulars and application form may be obtained from the Agent-General for New South Wales, 56 Strand, London, W.C.2, with whom applications should be lodged by July 31, 1958.

THE ASSOCIATION OF UNIVERSITY TEACHERS

APPOINTMENT OF EXECUTIVE SECRETARY

Applications are invited for this newly established post. The Executive Secretary will be responsible for the general administration of the work of the Association and particularly for the carrying out of its policy, which involves high-level negotiation and some public relations work.

Salary within the range £1,750 to £2,500 according to qualifications and experience, plus children's allowance and superannuation.

Further particulars may be obtained from the Honorary General Secretary, A.U.T., Laurie House, 21 Dawson Place, London, W.2, to whom applications (eight copies) should be sent before July 24, 1958.

MIDDLESEX COUNTY COUNCIL EDUCATION COMMITTEE

ENFIELD TECHNICAL COLLEGE
QUEENSWAY, ENFIELD, MIDDLESEX

Required for September 1, 1958: Lecturer in Physics to teach the subject to the standard of B.Sc. (General) Degree. Applicants should possess a good honours degree and preferably be Graduates or Associates of the Institute of Physics. Preference will be given to candidates with practical experience in some branch of applied physics. Salary in accordance with the Burnham (Technical) Report, 1956, i.e., £1,200 by £30 to £1,350 plus London allowance.

Application forms (stamped addressed foolscap envelope), from the Principal, to whom completed forms should be returned within fourteen days of the appearance of this advertisement.

C. E. GURR, M.Sc., Ph.D.,
Secretary to the Education Committee.

NORTHERN POLYTECHNIC

HOLLOWAY ROAD, N.7

The Governing Body invite immediate applications for appointment, as from September, 1958, as part-time Lecturers in:

(a) Mathematics for degree courses and for G.C.E. courses at Advanced and Ordinary Levels. Availability for day classes would be an advantage.
(b) English for evening classes at G.C.E. Ordinary Level.
(c) Chemistry for evening classes at G.C.E. Ordinary Level.

Apply, in writing, giving full particulars of age, qualifications, experience, etc., to the Secretary.

NATIONAL INSTITUTE OF APPLIED SCIENCE

LYON, FRANCE

Applications are invited from British science and engineering graduates for three Lecturer posts (physics, chemistry, and applied mechanics or technology) in this new technical college. The Lecturers will teach in English and will have opportunities for research. Salary: 60,000 frs. a month with accommodation facilities.

Apply to Scientific Office, French Embassy, 22 Wilton Crescent, S.W.1.

COLLEGE OF TECHNOLOGY

BIRMINGHAM
(Designated College of Advanced Technology)
DEPARTMENT OF MECHANICAL ENGINEERING

Applications are invited for the posts of: Senior Lecturers and Lecturers in Mechanical Engineering, specializing in either strength of materials, mechanics of fluids, thermodynamics, mechanics of machines or machine design. Candidates should have an honours degree or equivalent, teaching, industrial and/or research experience. An Assistant, Grade "B," is also required mainly for Engineering Drawing. Salary scale: Senior Lecturers (men), £1,350 by £50 to £1,550. Lecturers (men), £1,200 by £30 to £1,350. In fixing the commencing salary, account may be taken of industrial, professional or research experience up to the maximum of the scale. Assistants, Grade "B" (men), £650 by £25 to £1,025 with additional graduate and training allowances where applicable. In fixing the commencing salary, account will be taken of teaching and industrial experience.

Further particulars and forms of application from the Registrar, College of Technology, Gosta Green, Birmingham, 4, on receipt of stamped addressed foolscap envelope. Applications to be received within eighteen days of this advertisement.

K. R. PILLING,
Clerk to the Governing Body.

UNIVERSITY OF READING

Applications are invited for a post of Research Assistant in Zoology to work on the biology of fish populations in the River Thames. Candidates should be graduates in zoology or be candidates for honours this year. The assistantship is tenable for three years. Salary £310 per annum.

Applications should be sent, not later than July 19, 1958, to the Registrar (Room 22, O.R.B.), the University, Reading, from whom further particulars may be obtained.

UNIVERSITY COLLEGE LONDON

DEPARTMENT OF ZOOLOGY AND COMPARATIVE ANATOMY

Applications are invited for appointment as Research Assistant to join small group studying problems of morphogenesis. The work undertaken could be the subject of thesis for higher degree. Starting salary £550 per annum.

Applications, giving names of two referees, must be received not later than July 31 by the Secretary, University College, Gower Street, London, W.C.1, from whom further particulars may be obtained.

SIR JOHN CASS COLLEGE

JEWRY STREET, LONDON, E.C.3
RESEARCH ASSISTANTSHIPS

Applications are invited for Full-time Research Assistantships in the Departments of Botany and Zoology, Chemistry, Mathematics, Metallurgy and Physics. The Assistantships are tenable for two years with possible extension for a third year, and the approximate annual value is £500. Research Assistants will normally proceed to a higher degree of the University of London as full-time Internal Students, and will be required to undertake teaching duties not exceeding six hours weekly.

Further details and forms of application for awards tenable from September 1, 1958, may be obtained from the Secretary of the College.

D.S.I.R. HYDRAULICS RESEARCH Station, Wallingford, Berks, requires Senior Scientific Officer to investigate the mechanics of water waves, beach processes and harbour problems. Qualifications, first- or second-class honours degree preferably in civil or mechanical engineering, with good knowledge of hydraulics and at least three years postgraduate experience preferably of hydraulics research but scientific experience in wave-motion other than of water will be relevant. Salary range £1,130 to £1,330 (men). Prospects of promotion, and for candidates under 31 also of establishment. Good housing prospects for married staff.—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting E.225/8A. Closing date July 19, 1958.

UNIVERSITY OF SOUTHAMPTON. LECturer in Biochemistry. Applications are invited for the appointment of a Lecturer or Assistant Lecturer in Biochemistry in the Department of Physiology and Biochemistry. Salary scale: Lecturer, £900 by £50 to £1,350 by £75 to £1,650, with an efficiency bar at £1,300; Assistant Lecturer, £700 by £50 to £850.—Further particulars should be obtained from the Secretary and Registrar, to whom applications (seven copies from United Kingdom applicants) should be sent not later than July 16, 1958.

CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH LABORATORIES, LEATHERHEAD, SURREY

Applications are invited for the appointment of ASSISTANT ENGINEERS to work at the RESEARCH LABORATORIES AT LEATHERHEAD, SURREY, on a wide range of problems associated with conventional and nuclear power stations. Present investigations concern heat transfer in nuclear fuel elements and heat exchangers, electrostatic precipitators, cooling towers, and boiler feed pumps.

Candidates for senior vacancies should have an honours degree with previous research experience; for other vacancies a pass degree or H.N.C. with appropriate experience would be acceptable but importance is attached to ability to apply fundamental knowledge to a wide range of problems.

Salary, according to ability and experience: £1,160 to £1,510 per annum, £1,055 to £1,265 per annum, £820 to £995 per annum, £550 to £725 per annum.

Application forms from S. S. Scott, Chief Personnel Officer, Central Electricity Generating Board, 24/30 Holborn, London, E.C.1, to be returned by July 14. Envelopes should be marked "Confidential"—Ref. N./169.

UNIVERSITY COLLEGE OF THE WEST INDIES

Applications are invited for Lectureship in Anatomy from candidates with registrable medical qualifications. Duties include lecturing in human anatomy and assistance in practical courses in histology for medical degrees of London University. Salary scale (under review): £1,000 by £100 to £1,300 by £100 to £1,700 per annum, entry point determined by qualifications and experience. Child allowance. F.S.S.U. Unfurnished accommodation at rent 5 per cent basic salary. Passages for up to five persons on appointment, normal termination and triennial study leave. Duties to be assumed if possible by November 1, 1958.

Detailed applications (ten copies), naming three referees, by July 28, 1958, to Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1, who has further particulars.

ST. THOMAS'S HOSPITAL MEDICAL SCHOOL

LONDON, S.E.1

Applications are invited for the post of Assistant Lecturer in the Department of Chemistry and Biochemistry. The post will be tenable from October 1, 1958, or earlier if the successful candidate is available. Commencing salary, according to qualifications and experience, in the scale £850 by £50 to £1,050 per annum plus London allowance of £60. Membership of the F.S.S.U. and children's allowance scheme.

Applications, giving details of qualifications and the names of two referees, should be submitted by July 25, 1958, to the Dean, St. Thomas's Hospital Medical School, London, S.E.1, from whom further information may be obtained.

NORTHERN POLYTECHNIC

HOLLOWAY, LONDON, N.7

The Governing Body invite immediate applications for appointment as full-time ASSISTANT LECTURER (GRADE "B") IN TELECOMMUNICATIONS to teach up to the Final Certificate of the City and Guilds of London Institute and the R.T.E.B. Radio and Television Servicing Certificates. Salary scale: £650 by £25 to £1,025 together with allowances in accordance with the Burnham Award. Commencing salary according to age, qualifications and experience. Candidates should be graduates or the equivalent. Industrial and/or teaching experience an advantage. Apply for form of application and further particulars to the Clerk to the Governors.

UNIVERSITY OF BRITISH COLUMBIA

DEPARTMENT OF ELECTRICAL ENGINEERING

The Department has several openings and invites applications from persons well qualified in the following areas: (a) electrical machines and energy conversion (b) electrical materials, components and industrial applications; (c) microwave circuits and aptennae. Date of appointment July 1, 1951; duties commence September 1, 1958.

Further information may be obtained by writing to the Head of the Department or from the National Research Council of Canada, Africa House, Kingsway, London, W.C.2.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, S.W.3

DEPARTMENT OF CHEMISTRY

RESEARCH ASSISTANTSHIPS

Applications are invited from suitably qualified Chemistry graduates for two Research Assistantships in this Department. Each of the Assistantships will be of the value of £300 per annum, probably supplemented by a fee for part-time teaching (maximum six hours per week), and the successful candidate will be registered for an Internal postgraduate degree of the University of London. One of the research investigations will be in the field of Inorganic Chemistry.

Applications (giving two referees) should be sent as soon as possible to the Head of the Chemistry Department.

CENTRAL ELECTRICITY GENERATING BOARD

ASSISTANT ENGINEERS—NUCLEAR PLANT DESIGN BRANCH

ASSISTANT ENGINEERS required in Reactor Design Section of the Nuclear Plant Design Branch in the field of Health Physics. After an initial period of training successful candidates will be based at the Hinkley Point (Somerset) Power Station now under construction. Candidates should have a higher national certificate or degree, or have other suitable technical qualifications in physics, applied physics, chemistry, or electronics, preferably with some practical experience. Salaries within scales £820 to £995 or £1,055 to £1,265 per annum.

Application forms, obtainable from S. S. Scott, Chief Personnel Officer, 24-30 Holborn, London, E.C.1, should be completed and returned in envelopes marked "Confidential"—ref. N./171 by July 18.

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE

Applications are invited for the post of Demonstrator or Tutorial Student in Department of Chemistry. Applicants who expect to graduate this year will be considered. Remuneration: Demonstrators £550 per annum, Tutorial Students £500 per annum.

Applications should reach the Registrar, The College, Keele, Staffs, from whom further particulars and application forms can be obtained, not later than July 12, 1958.

UNIVERSITY OF MANCHESTER

Applications are invited for the post of Lecturer in Theoretical Physics. Salary on a scale £900 to £1,650 per annum with membership of F.S.S.U. and children's allowance scheme.

Applications should be sent not later than July 5, 1958, to the Registrar, the University, Manchester 13, from whom further particulars and forms of application may be obtained.

UNIVERSITY PANJAB, LAHORE, PAKISTAN, invites applications for the posts of Professors in Physical Chemistry, Organic Chemistry, Zoology, Botany, Mathematics (Applied), Mathematics (Pure), History, and Mineralogy and Geology. Requirements: high academic qualifications, established reputation in original research, teaching, and organization. No age limit. Salary according to qualifications.—Please obtain full information from Pakistan High Commission, London.

UNIVERSITY OF SOUTHAMPTON, ZOOLOGY Department. Research Assistant required as from September 1, 1958, to investigate effects of chemical pollutants on marine organisms (under grant from Atomic Energy Commission). Good degree in chemistry or biochemistry essential. Some research experience or qualification preferable. Maximum salary £600, according to qualifications.—Applications, including names of two referees, to reach the Professor of Zoology not later than July 19, 1958. Further particulars may be obtained from the Secretary and Registrar, University of Southampton.

RESEARCH FELLOWSHIPS IN GOVERNment Scientific Establishments: Senior and Junior Research Fellowships, tenable for three years, in a very wide range of subjects. Qualifications: normally first- or second-class honours degree and evidence of a very high standard of ability in research. At least two years' postgraduate experience expected for Junior Fellowships (three years for Senior Fellowships). Rates £1,100 to £1,350 for Senior Fellowships and £750 to £1,000 for Junior Fellowships. F.S.S.U. applies.—Write Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, for application form, quoting S.4798/58.

DERBY AND DISTRICT COLLEGE OF TECHNOLOGY

Principal: T. Hesp, Ph.D., M.Sc., F.R.I.C., A.M.I.I.A.

Applications are invited for the following two posts in the Chemistry Department: (a) Lecturer. Salary scale: £1,200 by £30 to £1,350. (b) Assistant, Grade B. Salary scale: £650 by £25 to £1,025 plus allowances for degree and training and up to twelve increments for approved industrial experience. The Department has a high proportion of advanced work including degree, postgraduate and research work. Candidates must have a good honours degree or equivalent, together with teaching, research or industrial experience and should be capable of teaching organic or inorganic chemistry to degree or G.R.I.C. standard. For the post of Lecturer candidates should offer specialized knowledge of an important modern branch of chemistry or chemical techniques.

Application forms and details of the post may be obtained from the Principal, Derby and District College of Technology, Derby, by whom completed applications should be received within two weeks of the appearance of this advertisement.

C. MIDDLETON,
Secretary to the Joint Committee.

Education Office,
Becket Street, Derby.

CITY OF LEICESTER EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY AND COMMERCE

Principal: R. E. Wood, M.Sc., F.Inst.P.

Applications are invited for the post of Assistant Lecturer (Grade B) in the Department of Biology. Applicants should possess a good honours degree in biological subjects, preferably in zoology with botany as subsidiary. Previous teaching experience an added qualification. Salary, Burnham Technical Scale, £650 by £25 to £1,025 per annum (men), £580 by £20 to £820 per annum (women) (plus equal pay increments), with degree and training allowances and increments for approved teaching and/or industrial experience and War Service.

Forms of application, to be returned as soon as possible, and further particulars can be obtained from the Registrar, College of Technology and Commerce, Leicester.

UNIVERSITY OF CAMBRIDGE

DEPARTMENT OF GEOGRAPHY

The Appointments Committee of the Faculty of Geography and Geology intend soon to appoint a Demonstrator in the Department of Geography to hold office from October 1, 1958. The appointment will be subject to the Statutes and Ordinances of the University. The closing date for applications is July 16, 1958.

Details may be obtained from the Secretary of the Appointments Committee, Department of Geography, Downing Place, Cambridge.

THE MEDICAL COLLEGE OF ST. BARtholomew's Hospital, West Smithfield, E.C.1. Applications are invited from men and women for the post of Demonstrator (Assistant Lecturer) in Chemistry (in the Department of Biochemistry and Chemistry), tenable as from October 1, 1958, or as soon as possible thereafter. The salary is on the scale £700 to £850 per annum plus £60 London allowance, together with children's allowance and membership of the F.S.S.U. The successful candidate will have good opportunities for research.—Applications, which should give details of qualifications and experience and the names of two referees, should be received not later than July 17, 1958, and should be addressed to the Dean of the Medical College, from whom further particulars may be obtained.

LABORATORY SUPERINTENDENT REquired by Nigeria Northern Region Medical Department for tour of 12/24 months in first instance, either (a) with prospect of pensionable employment in salary scale (including inducement addition) £750 rising to £1,284 a year, or (b) on temporary terms in salary scale (including inducement addition) £810 rising to £1,386 a year plus gratuity at rate £100/£150 a year. Commencing salary according to experience. Clothing allowance £45. Free passages for officer and wife. Assistance towards children's passages and maintenance grant up to £288 annually. Liberal leave on full salary. Candidates must be A.I.M.L.T. and must be experienced in all branches of pathology, bacteriology, and biochemistry. Duties include management of laboratory staff and stores and demonstration of laboratory methods.—Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M3C/44849/NF.

UNIVERSITY OF EDINBURGH AND SOUTH-EASTERN REGIONAL HOSPITAL BOARD

SCOTLAND

MEDICAL PHYSICS UNIT

Applications are invited from Physicists with experience in radiation physics and/or medical applications of radioisotope techniques for posts as Principal Grade Physicists (£1,550 to £1,850 per annum) and Senior Grade Physicist (£1,100 to £1,500 per annum). Members of the Unit apply physics to a wide range of medical problems in the hospitals in the Region and the University Faculty of Medicine, and there are excellent workshop facilities and technical assistance. The physical apparatus with which the Unit is concerned includes a 4 MeV. linear accelerator and a 2 MeV. Van de Graaff generator.

Applications should be sent, with the names of two referees, to the Secretary, South-eastern Regional Hospital Board, 11 Drumsheugh Gardens, Edinburgh, 3.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, LONDON, S.W.3

DEPARTMENT OF CHEMISTRY

Applications are invited for the post of Lecturer with special interests in Physical-Organic Chemistry. Postgraduate research experience is essential and previous academic teaching experience is desirable. Salary scale: men, £1,200 to £1,350; women, £1,097 3s. to £1,350, plus London allowance of £36 or £48 according to age.

Further particulars may be obtained from the Clerk to the Governors, by whom applications should be received not later than July 26, 1958.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, LONDON, S.W.3

DEPARTMENT OF PHYSICS

Head of Department: W. H. George, M.Sc., Ph.D.(Lond.), F.Inst.P.

Applications are invited for the post of Lecturer in Physics, up to the standard of the B.Sc. Special Degree of the University of London. Candidates should possess teaching and research experience. Ample time and facilities for research will be provided. Salary scale: men, £1,200 by £30 to £1,350; women, £1,097 3s. to £1,350, plus London allowance of £36 and £48 according to age. Placing on the scale will be in accordance with previous service in an equivalent capacity.

Particulars and form of application from the Clerk to the Governors. Last day for applications, July 11, 1958.

UNIVERSITY OF EDINBURGH

DEPARTMENT OF FORESTRY

Applications are invited for the appointment, for a period of three years, of a Research Worker to continue the special study of shelterbelt problems in Scotland by the Department of Forestry. Applicants should have a university degree, preferably in forestry, with some practical forestry and research experience. Salary scale £950 by £50 to £1,050 per annum. The successful applicant will be expected to take up duty not later than October 1, 1958.

Applications, with the names of two referees, should be lodged with the undersigned not later than July 18, 1958.

CHARLES H. STEWART,
Secretary to the University.

UNIVERSITY OF BELFAST

Applications are invited for a post as Research Assistant in the Department of Zoology from October 1, 1958, or such other date as may be arranged. Salary in the range £350 to £500 will depend on qualifications and experience. Applicants should be graduates in Zoology or Biochemistry with an interest in isotope and tissue culture techniques.

Letters of application should reach the undersigned by July 15, 1958.

G. R. COWIE, M.A., LL.B., J.P.,
Secretary.

UNIVERSITY OF SOUTHAMPTON, ZOOLOGY Department. Research Assistant required as from September 1, 1958, to investigate effects of chemical pollutants on marine organisms (under grant from Atomic Energy Commission). Good degree in biological science or physiology essential. Some research experience or qualification preferable. Maximum salary £550, according to qualifications.—Applications, including names of two referees, to reach the Professor of Zoology not later than July 19, 1958. Further particulars may be obtained from the Secretary and Registrar, University of Southampton.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Lecturer required in October, 1958, in the Pure Geochemistry Section of the Geology Department, having experience in rock and mineral analysis. Duties will include teaching petrology and research in pure geochemistry or chemical petrology. Salary in scale £900 by £50 to £1,350 (bar) by £75 to £1,650; plus £60 London allowance per annum, F.S.S.U. benefits and family allowances.

Apply to Professor D. Williams, Geology Department, Imperial College, London, S.W.7.

UNIVERSITY OF READING

Applications are invited for a Research Demonstratorship in Zoology at a salary of £400 per annum.

Further details may be obtained from the Registrar (Room 22, O.R.B.), the University, Reading, by whom applications should be received not later than July 19, 1958.

EXPERIMENTAL OFFICER REQUIRED TO assist in research on pig nutrition. The appointment will be in the Experimental Officer or Assistant Experimental Officer grade according to age and experience, and candidates should possess an appropriate degree or diploma. A superannuation scheme is in force. Salary scale (men): Experimental Officer, £920 to £1,130; Assistant Experimental Officer, £370 (age 18) to £800.—Applications, stating date of birth, with particulars of education and experience, and the names of three referees, should be sent to the Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire.

SENIOR TECHNICIAN, 1, WITH EXPERIence in bacteriology and another with experience in histology. Salary within range £650 to £790 per annum.—Apply to the Director, the Bernhard Baron Memorial Research Laboratory, Queen Charlotte's Maternity Hospital, Goldhawk Road, London, W.6.

MEDICAL RESEARCH COUNCIL UNIT, Department of Human Anatomy, University Museum, Oxford. Male graduate in physiology or biology is required for a programme of research for British Iron and Steel Research Association. The work will be concerned with physiological problems in the steel industry with opportunity to work for higher degree. Salary up to £700.—Apply by July 31 to Assistant Director.

MEDICAL LABORATORY TECHNICIAN. Vacancy will occur end of August. Qualified A.I.M.L.T., science degree or equivalent. Whitley conditions.—Apply, in writing, to Administrative Officer, North London Blood Transfusion Centre, Deansbrook Road, Edgware, Middlesex.

APPOINTMENTS VACANT

ELECTRON MICROSCOPY

Technician required by the British Rayon Research Association for non-routine work in an electron microscopy laboratory. The work will involve development and application of new techniques, and general ability and enthusiasm are more important than previous experience in this field. The post is pensionable and salary will be in accordance with age and experience.

Apply to the Secretary, British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester, 22, quoting ref. P.2.

RESEARCH CHEMIST, PREFERABLY with honours degree, is required to participate in the development of new products in an establishment outside Edinburgh. Initially the work will be concerned with synthetic organic chemistry, though a widening of field is anticipated. A salary of not less than £700 per annum is envisaged depending on qualification and experience.—Applications, which will be treated in confidence, should be sent to Box 671, T. G. Scott and Son, Ltd., 1 Clement's Inn, London, W.C.2.

SCIENTIFIC PUBLISHERS (LONDON) have vacancy for a male assistant on editorial planning. Applicants should have had previous experience in technical journalism or publishing, or have received formal training in a branch of science or technology.—Applicants should apply in writing, giving full particulars of training and experience, to Box 672, T. G. Scott and Son, Ltd., 1 Clement's Inn, London, W.C.2.

ENGLISH CLAYS LOVERING POCHIN & Co. Ltd., St. Austell, Cornwall, have a vacancy for an inorganic Research Chemist.—Applications are invited from well-qualified graduates and should be addressed in confidence to the Research Director, giving full career and personal particulars.

COMPUTER ENGINEERS

English Electric is considerably expanding its activities in the field of Digital Computers, and a number of qualified Engineers are required for their new Computer Laboratories, pleasantly located on the Staffordshire/Cheshire border. Qualifications for these positions are normally a degree or H.N.C., but consideration will be given to applicants with experience in pulse circuitry.

Unfurnished tenancies of recently built houses will be available after an initial period, the Company operates an attractive staff pension scheme and monthly staff are entitled to three weeks holiday from next year.

Please write, giving full details, to Dept. C.P.S., 336/7 The Strand, London, W.C.2, quoting reference N.306L.

PHYSICIST

The British Rayon Research Association has a vacancy for a Physicist for fundamental research into the structure and properties of yarns and fibres. A good degree in physics or equivalent qualification is required. Research experience would be an advantage, but is not essential. Salary in the range £650 to £1,100, with F.S.S.U.

Apply to the Secretary, British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester, 22, quoting ref. P.3.

TECHNICAL LIBRARY AND INFORMAtion Bureau requires male Assistant. Preferably 21 to 35 years with knowledge of chemistry and physics, French and German. Some acquaintance with biology useful. Good prospects. Five-day week. Staff restaurant and pension scheme.—Please apply to the Personnel Officer, Griffin and George Ltd., Ealing Road, Alperton, Middlesex.

THE COOPER TECHNICAL BUREAU (THE Research Organization of Cooper McDougall and Robertson Ltd.) requires a young graduate with an interest in insects of livestock importance. The work will be mainly concerned with the development and application of insecticides to animals. The appointment offers to the true field worker tremendous opportunities to develop his talents. Salary according to age, qualifications and experience.—For form of application apply The Director, Cooper Technical Bureau, Berkhamsted.

ALLEN AND HANBURYS LTD., WARE, Herts, invite applications for the post of Bacteriological Technician in the Pharmacology Department. Applicants should possess the Associateship of the I.M.L.T. in bacteriology; preference will be given to a candidate also experienced in histological techniques. The applicant will be required to participate in microbiological research and in the routine examination of drugs for their antimicrobial acton *in vivo* and *in vitro*.—Applications, stating age, present post and previous experience should be addressed to the Personnel Manager.

MICROSCOPIST WANTED BY AMERICAN Research Division of well-known firm engaged in manufacture of medical products. Applicants should be capable of establishing own research programme in fields of company interest which includes fibrous proteins, wound healing and collagen disease. Experience with electron as well as light microscopy required, knowledge of histochemistry desirable. Generous salary, dependent on qualifications.—Please send complete résumé, in the first instance to Box 670, T. G. Scott and Son, Ltd., 1 Clement's Inn London, W.C.2.

CHEMISTS PREFERABLY WITH HONOURS degree, required by The British Drug Houses Ltd., for Development Research in connection with organic chemicals. The work relates to bulk and fine chemicals and chemotherapeutic substances. Commencing salary will be according to qualifications and experience. Five-day week. Pension and profit sharing schemes. Canteen and Sports Club.—Apply, in writing, stating age, qualifications, experience and salary required, to Personnel Manager, Graham Street, City Road, N.1.

HEAT TREATMENT OF TEXTILES

The British Rayon Research Association is carrying out an extensive development programme on the application of fluidized beds to the heat treatment of textiles. Scientists who are interested in working in a completely new field, of vital interest to the textile industry, are invited to apply for the following situations:

(1) Mechanical Engineer to assist in the design and development of plant for drying and dyeing fabrics. Previous experience in heat transfer work would be an advantage. (Ref. M.D.2.)

(2) Chemist to undertake laboratory and pilot plant work on the application of dyestuffs to fabrics using the fluidized bed technique. Some knowledge of textile dyeing would be an advantage, but is not essential. (Ref. M.D.3.)

(3) Physicist to study the general physical properties of fluidized systems and to measure heat transfer coefficients under laboratory conditions. Applicants must have had at least three years' research experience and should preferably possess a Ph.D. degree. (Ref. M.D.4.)

The minimum qualification for all three posts is a good honours degree or its professional equivalent. For (1) and (2) the starting salary will be up to £1,100 per annum; for (3), which is a more senior appointment, the starting salary may exceed this figure. Working conditions are good, with a five-day week and a minimum of 15 days annual leave. Each post is superannuable under the F.S.S.U. scheme.

Apply to the Secretary, British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester, 22, quoting the appropriate reference number.

PHYSICAL CHEMIST PREFERABLY WITH some postgraduate experience, required for research on surface chemistry of inorganic materials. The successful candidate will also be expected to carry out X-ray diffraction work for the identification of materials as a service to other sections. Some experience in X-ray crystallography would therefore be an advantage, but is not essential. The laboratories are situated in pleasant rural surroundings in the Peak District, but within easily access of the Manchester area. Some assistance will be given with regard to house purchase in cases of successful applicants who are married.—Apply, in writing, giving full details of education, qualifications and experience, which factors will determine the starting salary, to the Personnel Manager, Ferodo Limited, Chapel-en-le-Frith, Via Stockport.

PHYSICAL CHEMISTS

The British Rayon Research Association has two vacancies for Physical Chemists: (1) to work on the mechanism of enzyme action in systems related to cellulose. (Ref. C.1.) (2) To work on the mechanism of gelation of high polymer solutions, with particular reference to fibre-forming polymers. (Ref. C.3.) Candidates should preferably be of Ph.D. standard. Salary up to £1,100, with superannuation under F.S.S.U. Some help may be given with accommodation.

Apply to the Secretary, British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester, 22, quoting the appropriate reference number.

KELVIN & HUGHES LTD., WINCHESTER Road, Basingstoke, Hants, have vacancies in their Systems Laboratory for Senior and Junior Development Engineers for work on the design of small electro-mechanical control systems. Applicants should have a degree or higher national certificate in electrical engineering and preferably several years' experience in the design and development of transistor amplifiers and servo mechanisms. The laboratories are housed in a modern building on the outskirts of Basingstoke. The Company has a staff pension scheme and housing accommodation will be made available to suitable applicants.—Applications should be made in writing, giving full details of qualifications, age, experience, etc., and addressed to the Personnel Manager.

THE WELLCOME FOUNDATION LIMITED invites applications for posts in the control laboratories attached to the Wellcome Chemical Works. In addition to routine analysis, the persons appointed will be required to carry out original work on the application of modern analytical chemistry to industrial problems. Candidates should possess an honours degree, or its equivalent, and it is desirable that they should have had some analytical experience, although this is not essential. The salary offered will depend upon age, qualifications, and experience. First-class staff conditions.—Applications should be addressed to the Personnel Manager, Wellcome Chemical Works, Dartford, Kent.

RESEARCH CHEMISTS. THE BRITISH Drug Houses Ltd. require for their Chemical Research Department (1) young Graduate for work in the steroid field. Previous experience desirable but not essential. (2) Newly qualified female Graduate interested in the application of physicochemical methods to the determination of structure. The Company's policy towards publication in scientific journals ensures recognition in authorship of scientific work undertaken by the Department. Five-day week, canteen, pension and profit-sharing schemes.—Write, giving details of studies, age, experience, and salary required, to the Personnel Manager (E.7451), Graham Street, London, N.1.

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Due to expansion of research and development activities on materials, processes, and new products in the resistor, capacitor and other fields, applications are invited for Physicists, Chemists, and Development Engineers. These should have appropriate qualifications, preferably to B.Sc. standard, with at least two years' industrial experience. Preferred aged from 25-35. Experience of the products involved is not necessary, adaptability is more important since facilities for training and gaining fresh experience will be made available.

Please apply to the Personnel Department, Kembrey Street, Swindon, Wilts.

SENIOR BIOCHEMIST OR MICROBIOlogist required for a laboratory engaged on fundamental research on cell respiration and metabolism. Applicants should possess a good honours degree and have had considerable post-graduate research experience. The appointee will be expected to show intiative and originality and will be given every scope to develop his own ideas. A high salary will be paid for outstanding qualifications and experience, and the position holds excellent prospects. There is a non-contributory pension scheme.—Applications, which will be treated in confidence, should give full details of qualifications and career, and should be sent to Box No. 667, T. G. Scott and Son, Ltd., 1 Clement's Inn, London, W.C.2.

STATISTICIAN. BRITISH NYLON Spinners require a Statistician to apply and develop statistical techniques on experimental and production problems. The position requires a man willing to accept responsibility and work in close liaison with other departments. Candidates should possess an honours degree in mathematics or statistics and while some industrial experience is desirable it is not essential. The appointment will carry a good starting salary, conditions of employment are of the highest, and there will be good opportunities for progress.—Applications should be sent to the Personnel Manager, British Nylon Spinners, Ltd., Pontypool, Mon.

THE BRITISH DRUG HOUSES LTD. HAS a vacancy in its Chemical Research Department for a young graduate (male or female) interested in preparative work. Some knowledge of steroid chemistry would be an advantage. Five-day week, canteen, pension and profit-sharing schemes.—Write, giving details of studies, age, experience (if any) and salary required, to Personnel Manager, Ref.VP.2, Graham Street, London, N.1.

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